United States
Department of
Agriculture

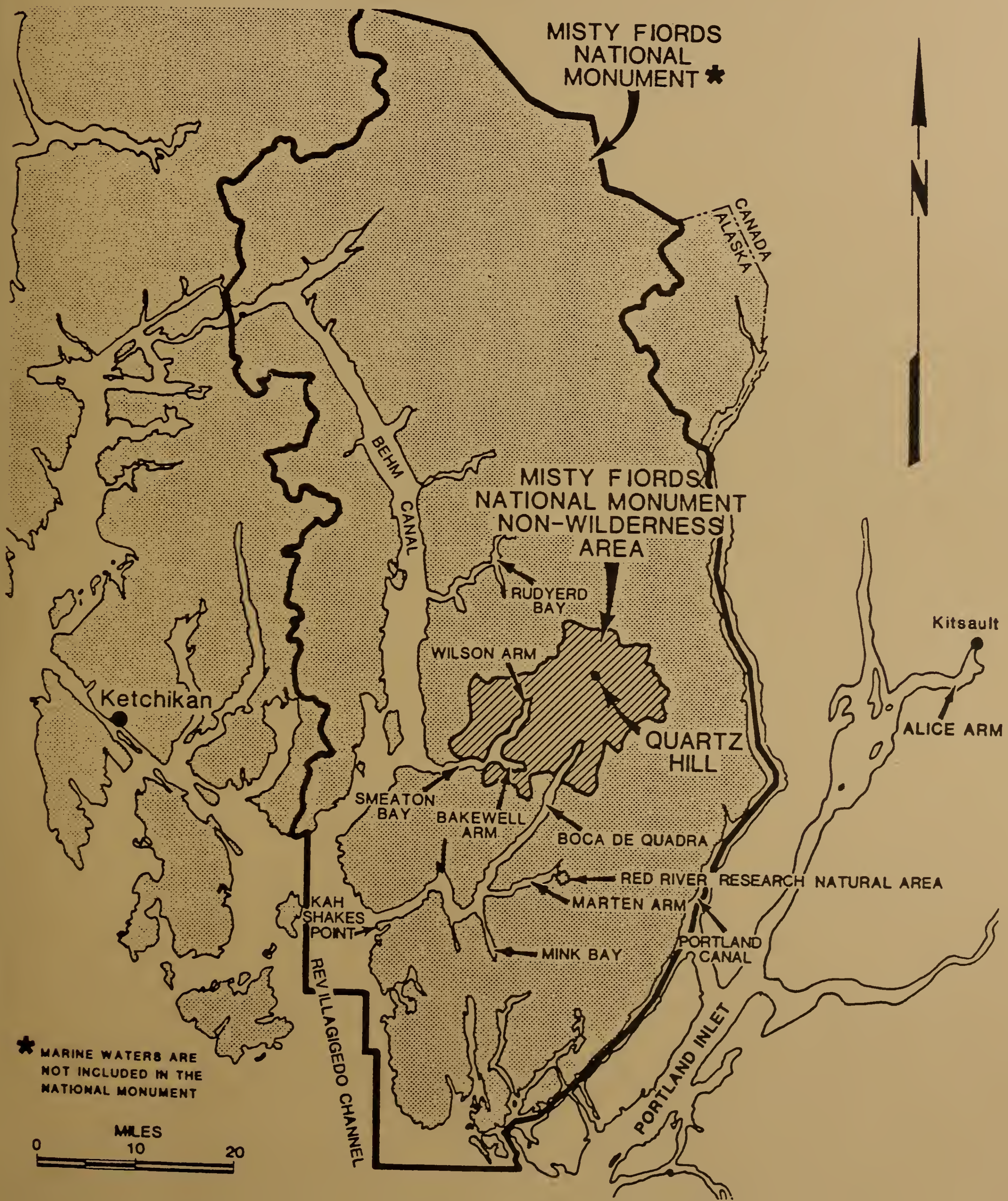
Forest Service

Tongass
National
Forest
R10-MB-41a

Quartz Hill Molybdenum Project Mine Development

Final Environmental Impact Statement

ABSTRACT


MISTY FIORDS NATIONAL MONUMENT *
CANADA
ALASKA
N
BEHM CANAL
MISTY FIORDS NATIONAL MONUMENT NON-WILDERNESS AREA
RUDYERD BAY
WILSON ARM
Kitsault
ALICE ARM
Ketchikan
QUARTZ HILL
SMEATON BAY
BAKEWELL ARM
BOCA DE QUADRA
RED RIVER RESEARCH NATURAL AREA
MARTEN ARM
KAH SHAKES POINT
MINK BAY
PORTLAND CANAL
REVILLAGIGEDO CHANNEL
PORTLAND INLET
* MARINE WATERS ARE NOT INCLUDED IN THE NATIONAL MONUMENT
MILES
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FINAL ENVIRONMENTAL IMPACT STATEMENT
QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT

U.S. Borax Molybdenum Claims at Quartz Hill
Tongass National Forest, Alaska

Lead Agency: U.S. Department of Agriculture, Forest Service
Tongass National Forest
Federal Building
Ketchikan, Alaska 99901

Responsible Official: Michael Barton, Regional Forester, Alaska Region, Juneau, Alaska

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Abstract: U.S. Borax & Chemical Corporation has proposed constructing and operating a nominal 80,000 ton-per-day molybdenum mine and processing facility at the Quartz Hill site, 45 miles east of Ketchikan, Alaska. The construction and operation of the proposed project would require issuance of special use permits and leases by the Department of Agriculture, Forest Service, under the authority of the Alaska National Interest Lands Conservation Act (ANILCA); issuance of at least one Department of the Army permit by the U.S. Army Corps of Engineers, under the authority of Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of the Clean Water Act; and issuance of National Pollutant Discharge Elimination System (NPDES) permits by the U.S. Environmental Protection Agency under the authority of the Clean Water Act. The mine development project would consist of an open pit mine, waste rock disposal areas, ore crushing and transport, a concentrator, tailings transport and disposal, employee housing and support facilities such as roads, water supply, wastewater treatment, and power supply. Nine alternative project concepts were investigated including the proposed project and the no action alternative. The proposed project includes a mill in Tunnel Creek, marine tailings disposal in Wilson Arm, and workers living in single status housing at the project site and commuting during days off to Ketchikan. The other alternative concepts are the following:

(1) No Action

(2) Tunnel Creek Mill with Boca de Quadra Tailings Disposal and either a Commute Option or a Townsite either at Bakewell Arm or at one of two sites near the mouth of the Wilson River.

(3) Tunnel Creek Mill with Wilson Arm Tailings Disposal and a Townsite

(4) Beaver Creek Mill with Boca de Quadra Tailings Disposal and either a Townsite or Commute

(5) Beaver Creek Mill with Wilson Arm Tailings Disposal and either a Townsite or Commute

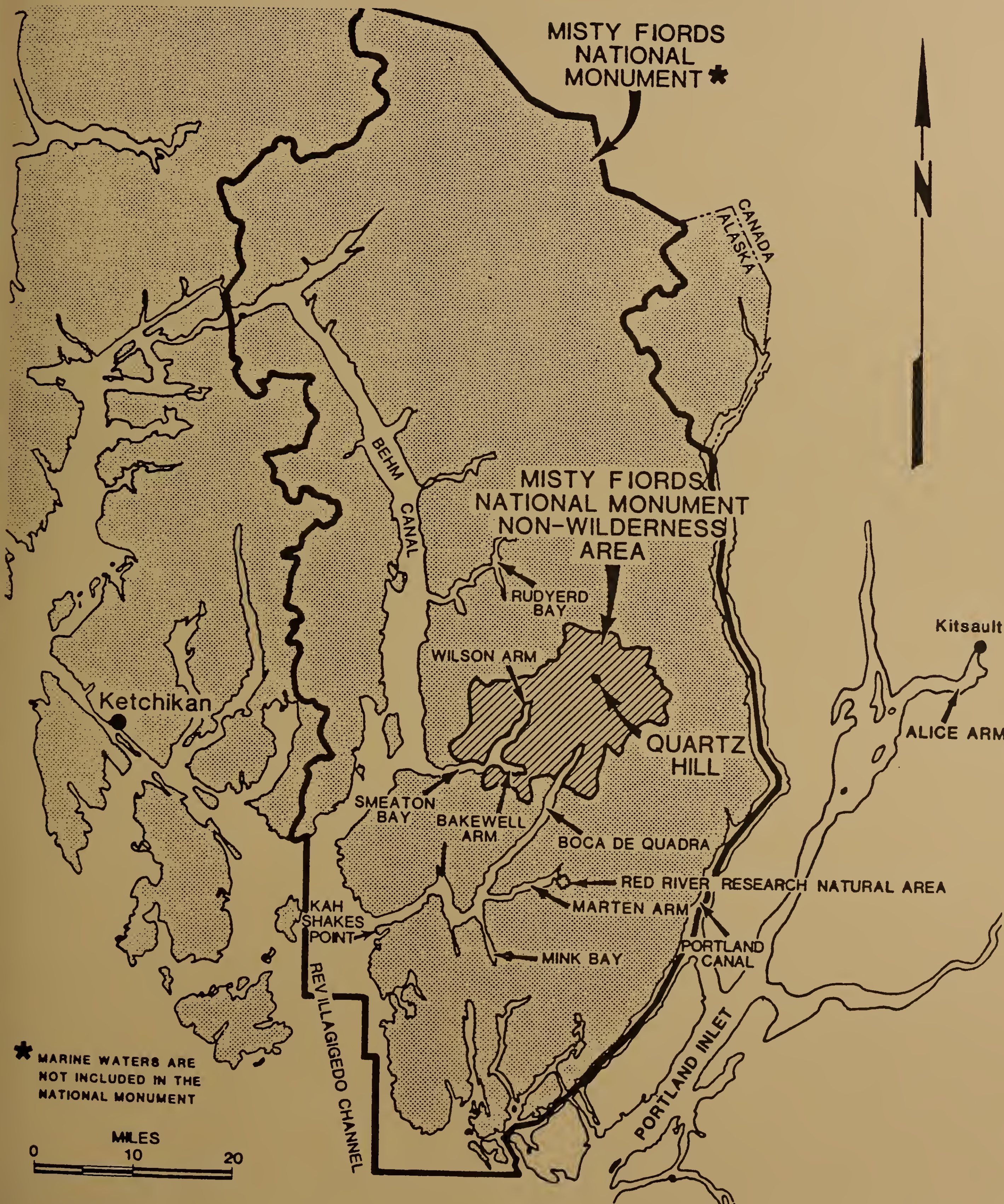
(6) Beaver Creek Mill with On-Land Tailings Disposal and either a Townsite or Commute

(7) North Meadow Mill with Boca de Quadra Tailings Disposal and either a Townsite, including the possibility of a site near the mouth of the Keta River, or Commute (the "Keta Alternative")

(8) North Meadow Mill with On-Land Tailings Disposal and either a Townsite or Commute.

Several subalternatives were also investigated including, but not limited to, disposal of tailings to the inner basin versus the middle basin of Boca de Quadra, the immediate versus phased-in development of a townsite, alternate tailings tunnel alignments, and alternate water supply sources. Impacts of each alternative were evaluated and mitigation measures were identified.

Cooperating Agencies: Alaska Department of Commerce and Economic Development
Alaska Department of Community and Regional Affairs
Alaska Department of Environmental Conservation
Alaska Department of Fish and Game
Alaska Department of Natural Resources
Alaska Department of Transportation and Public Facilities
Ketchikan Gateway Borough
National Marine Fisheries Service
Southern Southeast Regional Aquaculture Association
U.S. Army Corps of Engineers
U.S. Bureau of Mines
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service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SUMMARY

United States Borax & Chemical Corporation (U.S. Borax), acting on behalf of its affiliate, Pacific Coast Molybdenum Company, the owner of the Quartz Hill property, has submitted a Plan of Operations to develop a molybdenum mine to the U.S. Department of Agriculture, Forest Service, Tongass National Forest.

The construction and operation of U.S. Borax's proposed nominal 80,000 ton per day (tpd) molybdenum mine, processing facility, and appurtenant facilities would require issuance of special use permits and leases by the Department of Agriculture, Forest Service, under the authority of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980; issuance of at least one Department of the Army permit by the U.S. Army Corps of Engineers (Corps), under the authority of Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act; and issuance of National Pollutant Discharge Elimination System (NPDES) permits by the U.S. Environmental Protection Agency (EPA) under the authority of the Clean Water Act. A determination of consistency with the standards of the Alaska Coastal Zone Management Act of 1977 is also required. Numerous other permits would be required in addition to these principal permits.

The proposed project, known as the Quartz Hill Molybdenum Project, is located approximately 45 air miles east of Ketchikan, Alaska, in the Misty Fiords National Monument (Figures S-1 and S-2). ANILCA established the Monument and designated all but 152,610 acres (ac) as a wilderness. The non-wilderness area, enclosing U.S. Borax mining claims, allows for development of this project. ANILCA also specified that environmental resources of the area must be protected. The Forest Service has determined that an Environmental Impact Statement (EIS) is required to support federal action on the Plan of Operations. It has been determined that issuance of the permits and leases by the Forest Service, the Corps, and the EPA would be major federal actions significantly affecting the human environment. This decision was made pursuant to the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA.

U.S. Borax initiated a geochemical exploration program that resulted in the discovery in 1974 of a significant molybdenum deposit. The discovery led to the acquisition of rights to this deposit by the location of mining claims, which have recently been patented, under the federal mining laws. Exploration and sampling and environmental baseline programs were undertaken. As specified by ANILCA, two major documents have been prepared, the Mining Development Concepts Analysis Document (CAD) and the EIS for the surface access road and the bulk sampling phase. An EIS for U.S. Borax's 1980-1983 Plan of Operations, Amendments 2, 3, and 4 was also completed by the Forest Service. The Forest Service has granted a special use permit for the bulk sampling access road, and the Corps authorized construction of the wharf and the portions of the road within its jurisdiction. The road and wharf are now complete, have been accepted by the Forest Service, and are in use.

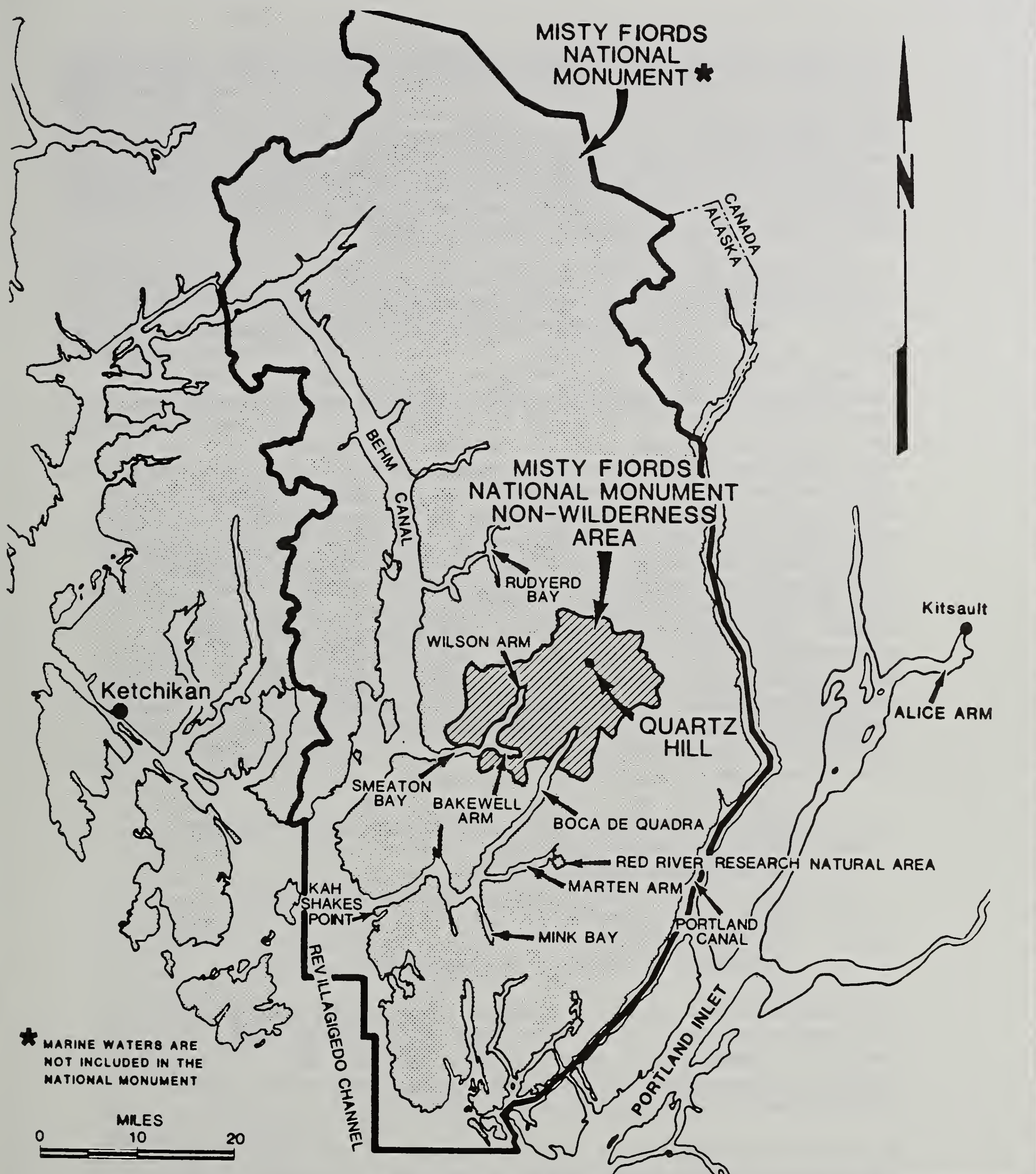
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

REGIONAL LOCATION MAP

SOURCE U.S. BORAX DATE FEB 84

FIGURE
S-1

envirosphere company
A Division of EBASCO SERVICES INCORPORATED



U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE S-2
GENERAL PROJECT LOCATION	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE U.S. FOREST SERVICE DATE NOV 83	

This Final EIS addresses the environmental impacts of the construction, operation, and post-mining abandonment of a mine, mill, and associated facilities at the Quartz Hill site as specified in the Road Access and Bulk Sampling EIS. A draft EIS (DEIS) was made available for review by the public and federal, state, and local agencies in August 1984. As a result of changes in the proposed project and new data since the DEIS, the Forest Service also issued a revised draft EIS (RDEIS). The RDEIS was made available for review on May 1, 1987.

As required by the final regulations implementing NEPA, the Forest Service has provided for an early and open process to determine the scope of issues to be addressed and to identify the significant issues related to the proposed project. The Forest Service accomplished this in two principal ways: by forming an interdisciplinary team (IDT) including representatives from public agencies and U.S. Borax to identify issues and to establish the scope of the EIS, and by holding a public scoping meeting. The IDT is comprised primarily of representatives of all federal and State of Alaska cooperating agencies that have jurisdiction or responsibility for maintaining the environmental quality or managing the natural resources of the Quartz Hill area. Early IDT meetings were held to identify significant issues that would be addressed in the EIS. Several other IDT meetings, as well as meetings with agencies and community representatives, have been held during the development of the EIS. As part of its scoping process, the Forest Service invited participation from other governmental groups, organizations, and individuals at the Public Scoping Meeting on January 19, 1983, in Ketchikan. All written and oral presentations from the Public Scoping Meeting were considered and incorporated into a list of significant issues. Significant issues identified by the public and the IDT are included within the following broad categories:

- Impacts of project water supply on area watercourses
- Tailings disposal impacts
- Fisheries habitat protection
- Worker housing and possible impacts to Ketchikan
- Water quality protection
- Impacts of project activities on wildlife and habitats
- Protection of adjacent wilderness area values.

Following the DEIS, a public workshop and a public meeting were held, and comments on the DEIS were received until October 1984. Following the RDEIS, comments were received until June 30, 1987. The public interest review process of the Corps for the work within their jurisdiction is concurrent with this EIS.

U.S. Borax has defined its proposed project in its Plan of Operations. This proposed project and several reasonable alternative project concepts are described and evaluated in this EIS. Each project concept consists of components such as an open pit mine, waste rock dumps, crusher and ore conveying facilities, a processing facility, tailings transport and disposal facilities, housing, and ancillary facilities

such as roads, water supply, wastewater treatment facilities, and power supply. The various components can be combined into several overall project layouts.

The components and impacts of the proposed project and alternatives are described below. Impacts of each of the alternatives are compared to those of the proposed project. In cases where the impacts are the same or very similar to the proposed project, they are not described again. The no action alternative would result in no further development of the proposed facilities. However, U.S. Borax has patented mining claims and would retain certain rights. ANILCA provisions would likely permit U.S. Borax to leave the bulk sampling access road and wharf in place. Only minor continuing impacts would result from the no action alternative.

Development of the proposed project and alternatives would require the following facilities:

- Mine Site Facilities - The ore body would be mined by open pit methods. Initial production would be a nominal 40,000 tpd, increasing to 80,000 tpd after approximately 5 years. Actual daily tonnages could vary 10 to 15 percent above or below the nominal rate. At this nominal rate mining would continue for a total of approximately 55 years. The pit would occupy 1,040 ac and have a final depth ranging from 1,325 to 1,875 ft and be approximately 2 mi long and 1.3 mi wide. Waste rock from the pit would be deposited in the valleys of Beaver Creek, White Creek, and Hill Creek. A crusher, equipment maintenance facility, ore conveyor tunnel, and water quality control ponds would be located adjacent to the pit area. Approximately 2,000 ac would be disturbed by the waste rock dumps, access roads, and ancillary mine site facilities. Operational reclamation, including seeding and stabilization, would take place during the life of the mine. Post-mining reclamation would be aimed at shaping, stabilizing, and revegetating the disturbed areas to minimize conflicts with natural landforms and to prevent the need for long term maintenance. Reclamation activities presently planned would include topsoiling and vegetating the waste rock dumps, performing some shaping of the dumps to provide adequate drainage, stabilizing sedimentation ponds and water supply dams, removing mine related structures, permanently closing all tunnels, and allowing the open pit to fill with water and become a lake. A formal plan will be developed that may select alternatives to the above.

  One alternative to the proposed project could involve diversion of upper Hill Creek to North Creek to prevent this runoff from draining through the waste rock dumps.

  A temporary shutdown of project operations could occur as a result of unfavorable market conditions. In this case, most employees would be laid off, but essential equipment maintenance and environmental permit compliance programs would continue.

- Ore Processing Facilities - The ore processing facilities where molybdenite would be physically separated from the host rock would be located on the north side of Tunnel Creek in the proposed project. The ore would be transported to the mill via a conveyor system in a 4-mi-long tunnel. The Tunnel Creek mill and proposed power plant, housing facilities, and ancillary facilities would occupy about 210 ac.

  Alternative mill locations could be at Beaver Creek or in North Meadow. Both of these sites are at high elevations where high snowfall occurs.

- Tailings Disposal Facilities - In the proposed project, tailings would be transported from the Tunnel Creek mill site through dual pipelines to an outfall in Wilson Arm. The tailings would be discharged into Wilson Arm at a depth of approximately 150 ft.

  Several tailings disposal alternatives have been investigated. Tailings could be transported through a 5-mi-long tunnel to an outfall in the inner basin of Boca de Quadra. The Boca de Quadra Tunnel portal would occupy 25 ac. Discharge would be at a depth of approximately 150 ft. After several years of operation, the outfall could be extended to the middle basin of Boca de Quadra. Alternatively, disposal could be to the middle basin throughout the life of the mine by way of a tunnel directly to the middle basin. On-land tailings disposal could be accomplished using large dams, 1,000 ft and 780 ft high, in Tunnel and Aronitz creeks, respectively. On-land tailings disposal would eliminate the possibility of a Tunnel Creek mill site.

- Housing Facilities - During construction and operation of the project, single status employee housing facilities would be provided at the project site. During the preproduction phase, the peak work force of 1,270 would be housed at the project site on a full-time basis. Workers would be transported to Ketchikan only for brief work breaks and for vacations. Construction housing would include floating camps early in the construction period, followed by land-based camps at Tunnel and Beaver creeks. During the operations phase in the proposed project, workers would commute on a weekly basis from Ketchikan to the project site, where they would be housed in employee housing facilities adjacent to the mine in Beaver Creek and adjacent to the mill in Tunnel Creek. During the period when expansion to 80,000 tpd occurs, the peak work force, including operations and construction workers, would be 1,130. Within the first 20 years of mining, the permanent work force is estimated at 1,020.

  Alternative employee housing plans during the operations period could involve construction of a full service townsite in the vicinity of the project. Scheduling of the townsite development could either provide for a complete townsite at the start of operations for the entire work force, or a phased-in townsite that

would be developed in stages and would reach full development only after several years. Alternate townsite locations are adjacent to Bakewell Arm, two sites near the Wilson River, and one near the mouth of the Keta River.

o Wharf Facilities - For the proposed project, wharf facilities at the present site on Wilson Arm would be expanded southward (downfjord) to provide necessary facilities. The wharf, a key access point during construction and operation, would occupy approximately 10 ac and extend along about 2,500 ft of shoreline. Mooring and two submarine pipes and hoses would be provided for unloading a 35,000 dead weight ton (dwt) fuel oil tanker. In addition to the wharf facilities, tanks for diesel and fuel oil would be located about 3,500 ft north on the landward side of the mine access road.

  Alternatively, the wharf could be located upfjord of the existing wharf on Wilson Arm. With a Keta access road, the wharf would be located on Boca de Quadra.

o Mine Development Road and Access Roads - Roads for the proposed project would include the mine development road along the Blossom River route, which would be double the width of the bulk sample access road and generally follow its alignment, and the mill access road along Tunnel Creek. Short secondary access roads would also be required.

  The primary alternative for mine access could be a Keta access road following an alignment along the Keta River and Hill Creek valleys. If a town is developed, an access road could connect with the mine access road.

o Electric Power Supply - For the proposed project, electric power would be supplied by a 95 MW combined-cycle, combustion-turbine plant located adjacent to the mill in Tunnel Creek. During construction, power would be provided by diesel powered generators.

  Alternative power plant locations include sites adjacent to the Beaver Creek or North Meadow mills.

o Water Supply - The water supply of approximately 16,000 gallons per minute (gpm) for process requirements would be provided from a reservoir on Tunnel Creek, supplemented during low flow periods by withdrawals from intake facilities on the Blossom River. This supplemental water supply would be for the proposed project or other alternatives that include a Tunnel Creek mill. Smaller water supplies needed for other project facilities would be developed from local water wells or surface water diversions.

  Alternative process water supplies would be needed for alternate mill sites. For the Beaver Creek mill site the water supply could be obtained from a reservoir on Raspberry Creek and the Blossom

River. The water supply for the North Meadow mill could be from a reservoir on upper Hill Creek with supplemental supplies from the Hill Creek sedimentation pond.

Alternative water supply sources have also been considered for the Tunnel Creek mill site. These alternatives included a Raspberry Creek reservoir as a supplemental water supply, an Upper Hill Creek reservoir as a supplemental source, a North Meadow reservoir as a primary or supplemental supply, a well field on the Wilson River as a primary or supplemental supply, and Tunnel Creek as a sole source with a larger reservoir.

Impacts on the existing environment of the project area would result from the proposed project or the development alternatives. The most significant of these impacts, and potential mitigation measures, in the order of their discussion in the EIS, include the following:

- The Quartz Hill project is considered to be two distinct and separate air quality sources. The Tunnel Creek power plant site is subject to the requirements of the Prevention of Significant Deterioration (PSD) program. The SO_2, NO_x, and carbon monoxide emissions are limited such that air quality impacts would be much less than the allowable PSD increments or Alaska State Ambient Air Quality Standards (ASAAQS). The mine site includes an ore crusher which is subject to New Source Performance Standards; however, emissions at the site would not be high enough to key PSD. The ambient concentrations would comply with ASAAQS. On-land tailings disposal would result in increased fugitive dust emissions throughout the mine life from construction of the tailings dams. A townsite might cause exceedences of the PSD particulate increment because of the use of wood burning stoves. This could be mitigated by imposing restrictions on wood stove use.

- The molybdenum ore body would be removed and used. This would be an irreversible and irretrievable commitment of a resource. Topographic impacts would result from the excavation of the pit. With on-land tailings disposal, substantial alterations of the existing topography would occur in the Tunnel and Aronitz creek valleys.

- The hydrologic regime of virtually all of White Creek and substantial portions of Hill and Beaver creeks would be essentially eliminated by development of the waste rock dumps and the open pit. Flows in downstream portions of Hill and Beaver creeks would be altered somewhat. Flows of some streams would be impacted by withdrawals of process water: Tunnel Creek for a Tunnel Creek mill, Raspberry Creek for a Beaver Creek mill, or Hill Creek for a North Meadow mill. Impacts would be minimal on the Keta River. Supplemental water withdrawals from the Blossom River would also result in minimal impacts. Wilson River impacts would result from withdrawals from the Wilson River well field during low flow periods if a Wilson River well field were utilized for water supply. Alternate water supply reservoirs would impact flows of the Blossom and Wilson rivers. On-land tailings disposal would

result in additional impacts, destroying most of the hydrologic regime of Tunnel and Aronitz creeks. If an upper Hill Creek diversion is constructed, flows in Hill Creek would be decreased somewhat, while North Creek flows would be substantially increased. Mitigation of low flow impacts would consist of the maintenance of instream flow requirements.

- Water quality impacts would result primarily from increased sediment loads, particularly during construction, and from unlikely, but potential, spills of fuels and chemicals. Likelihood of a spill would be increased with a Beaver Creek or North Meadow mill site. Although additional impacts could result from discharges from project related facilities, these impacts would be minimized since water quality control facilities would be designed and operated such that discharges would meet NPDES effluent limitations and other applicable standards.

- With the proposed project, Wilson Arm/Smeaton Bay would be impacted by the submarine deposition of tailings. The below-sill depth would be about 78 percent filled and small concentrations of the tailings fines would flow over the outer sill and into Behm Canal. Impacts would change the fjord's bathymetry and circulation pattern, but no significant effects are expected in the upper waters. With the proposed project, all impacts would be in the Wilson/Smeaton basin and no impacts would extend to the Boca de Quadra basin. With tailings disposal into the inner basin of Boca de Quadra, the below-sill depth of the inner basin would be filled and much of the tailings would flow into the deep middle basin. Inner basin bathymetry and circulation would be substantially changed, but impacts to the upper waters are not expected. With middle basin disposal initially, impacts to the middle basin would be similar, but impacts to the inner basin would be reduced or eliminated. With Boca de Quadra disposal, no tailings impacts to Wilson Arm/Smeaton Bay would occur. On-land tailings would eliminate impacts to both fjords.

- The chemical oceanography of Boca de Quadra or Wilson Arm/Smeaton Bay, depending on the alternative, would be affected by the discharge of the mill tailings including solids, dissolved trace metals, and milling reagents. Most impacts to the fjord's water quality would be in the near field discharge plume and the turbidity plume, a layer near the bottom. Water quality impacts could include increased dissolved molybdenum and manganese concentrations, which would be of little consequence. On-land tailings disposal would eliminate chemical oceanographic impacts.

- Blasting noises would cause short-term noise each day in the wilderness area of Misty Fiords National Monument. Project noise and activity could also disturb mountain goat populations in the vicinity, possibly forcing them to abandon a substantial part of their present habitat in the project area.

- Avalanche danger in the project area would be high and, even with control procedures, could lead to property damage, personal injury, and loss of life. To the extent feasible, project facilities have been sited to minimize exposure to avalanche hazards. With a North Meadow mill, a Keta townsite, and/or a Keta access road, employees would be exposed to considerable additional avalanche danger. A road to the Bakewell townsite could also increase worker exposure to avalanche hazards.

- Impacts to freshwater fisheries would be reduced by maintenance of instream flow requirements, including flushing flows, and by treating effluent to meet NPDES effluent limitations and Alaska Department of Environmental Conservation (ADEC) receiving water quality standards. Therefore, most impacts on freshwater ecology would be relatively minor. Suspended sediment during severe storm events could result in minor fish losses. The potentially most severe impacts could result from a major spill of fuels or chemicals; however, the probability of such a spill is low. With on-land tailings disposal, fisheries in Tunnel and Aronitz creeks would be largely eliminated by the impoundments. Townsite development would increase fishing pressure on local stocks. Several means have been identified to mitigate any impacts that may occur. These include gravel cleaning to remove fine sediment, streamside gravel incubation boxes to supplement salmon production, creation of a spawning channel, and construction of fishways and barrier modifications to provide access to increased habitat.

- Marine tailings disposal would impact marine ecology by burial of marine organisms and habitats, direct effects of suspended sediments, and possibly by toxicants present in tailings. Burial of several important bottom dwelling species would occur in affected areas. Potential habitat for herring would be occupied by tailings and/or suspended sediments to varying degrees depending on which basin receives the tailings. Migration of anadromous fish would not be affected, and all tailings impacts to salmon would be insignificant. On-land tailings disposal would eliminate most potential impacts to marine ecology.

  Increased fishing pressure would result from townsite development. Mitigation measures for marine biology impacts could include developing new intertidal or tidal marsh habitat by selective filling.

- Vegetation would be cleared from approximately 2,900 ac for project construction; however, this would be an insignificant impact on a regional scale. If on-land tailings disposal is used, an additional area of approximately 2,700 ac would be disturbed. Although considered a low probability event, a major fuel oil spill and subsequent cleanup operations near either the Wilson River or Keta River estuary could result in very significant impacts to the estuarine habitat.

- Several bald eagle nesting sites are located near planned construction areas. Mountain goat populations in the project area could be reduced by project activities. On-land tailings disposal would result in a doubling of the area of lost wildlife habitat. A townsite would disturb wildlife habitat and increase the likelihood of pressure on wildlife from hunting and incidental harassment. Mitigation measures could include a "Bald Eagle Protection Plan" to reduce construction impacts on nesting sites, regulations on employees to prevent disturbance of wildlife, and transplant projects to establish new populations of mountain goats in presently unused areas.

- Both positive and negative impacts on the area's socioeconomics would result from the project. New employment would consist of direct and indirect employment for about 1,800 at the peak construction level, and approximately 2,000 during project operations. If a townsite is built, additional construction workers would be required. The economy of the Ketchikan Gateway Borough (KGB) and of the region would receive benefits from the approximately $54 million in annual wages generated by the project. A townsite could divert some of these benefits from Ketchikan. The population of Ketchikan would increase as the result of in-migration of workers to the project. Even with the townsite or phase-in options, Ketchikan growth would be accelerated, although with these options growth would be rapid for a short period, followed by more gradual growth.

  Increased economic activity and an increased population base would result in increased opportunities for existing businesses, short-term price increases, and an influx of new businesses. A sudden demand for new housing could result in new, perhaps poor quality, construction and an increase in prices. The townsite or phase-in option could result in demand for more temporary housing rather than permanent housing. Some public services and facilities would have to be expanded to meet the increased demand. Some of the public expenditures would be offset by project-related revenues resulting from Quartz Hill employment and personal income; however, U.S. Borax would not be paying local property taxes for any of the mine area facilities. The timing of revenues from the project may not coincide with the timing of the need for additional services and facilities, particularly those needed to prepare for the initial population influx. User fees and state funding could reduce these financial impacts. If a temporary shutdown occurred, most employees would lose their jobs. Some would leave the area, while most would seek temporary jobs or unemployment benefits. Related effects could impact local businesses, housing, tax revenues, and social services.

  Mitigation measures that will reduce socioeconomic impacts have been identified. U.S. Borax and the Ketchikan community have entered into an agreement (Appendix I) which provides a process for mitigating adverse socioeconomic impacts that may occur as a result of this project. A few of the specific measures considered include

a publicity program to discourage excessive in-migration, a job training program for local residents, a procurement plan to allow local businesses to compete effectively for project contracts, a housing demand plan, financial assistance and services to the community by U.S. Borax, and native Alaskan project employment. Measures to manage growth and upgrade currently overloaded public services and facilities would need to be undertaken by local governments in order to complement mitigation measures implemented by U.S. Borax.

- The project would generate state revenues through taxes on individuals and small businesses, corporate taxes paid by Alaskan firms doing business with U.S. Borax, and corporate taxes paid by U.S. Borax. During the first few years of project operation, when the company tax liability would be low, the cost of providing state services to the project-related population may exceed additional tax revenue. Over the long term, state expenditures and revenues attributable to the project are expected to be roughly equal. If a temporary shutdown occurred, the state would continue to pay for services for the project-related population, while tax revenues would be lost. The most significant national economic effect is likely to be its positive impact on the nation's international trade balance.

- The project and its associated noise and visual impacts would change land use of the immediate area to an industrial one. Land ownership would not change from current conditions, but areas for project facilities would be leased to U.S. Borax by the Forest Service.

- Recreational use of Misty Fiords National Monument and the adjacent marine waters would increase, possibly displacing some current users. The quality of wilderness recreational experiences of some current users could also be diminished by noise and visual impacts. The location of a townsite near the project would greatly increase recreational activities due to use by townsite residents and visitors. The location of the townsite in the area and increased use could result in further displacement of current users and further reduction of wilderness values.

- Visual impacts would result from the introduction of an industrial facility into a natural area. Surface viewers would be affected principally by the wharf, the mill and power plant, and the tunnel portal facilities. Viewers in aircraft would be able to view the pit and mine area facilities. With on-land tailings disposal, impacts would be increased by the visual effects of the large dams in the Tunnel and Aronitz valleys.

Preferred Alternative

The preferred alternative for mine development is to locate the ore processing facilities in the Tunnel Creek valley, generate electric power for the mine on-site, not allow creation of a townsite, access the mine along the route of the existing bulk sample access road, and obtain processing water from an impoundment on Tunnel Creek.

When the mine production is increased from the initial 40,000 tpd capacity to 80,000 tpd, the water supply may be supplemented from a location near the mouth of the Blossom River. Water withdrawals from both Tunnel Creek and the Blossom River will be managed so that an instream flow is maintained sufficient for present and future productivity of fish habitat.

The Forest Service preferred alternative for tailings disposal is marine disposal in Wilson Arm/Smeaton Bay. The EPA concurs with the Forest Service preferred alternative. Impacts of the discharge will be evaluated through a monitoring program developed by the EPA in conjunction with issuance of an NPDES permit for the tailings discharge. The monitoring is primarily intended to ensure that unreasonable degradation to the aquatic environment is not occurring. The NPDES permit will be designed to avoid exceedance of water quality criteria outside the mixing zone for the discharge. Depending on the results of the monitoring program, the permit for tailings disposal may be modified or even terminated if necessary prior to the completion of the design life of the project.

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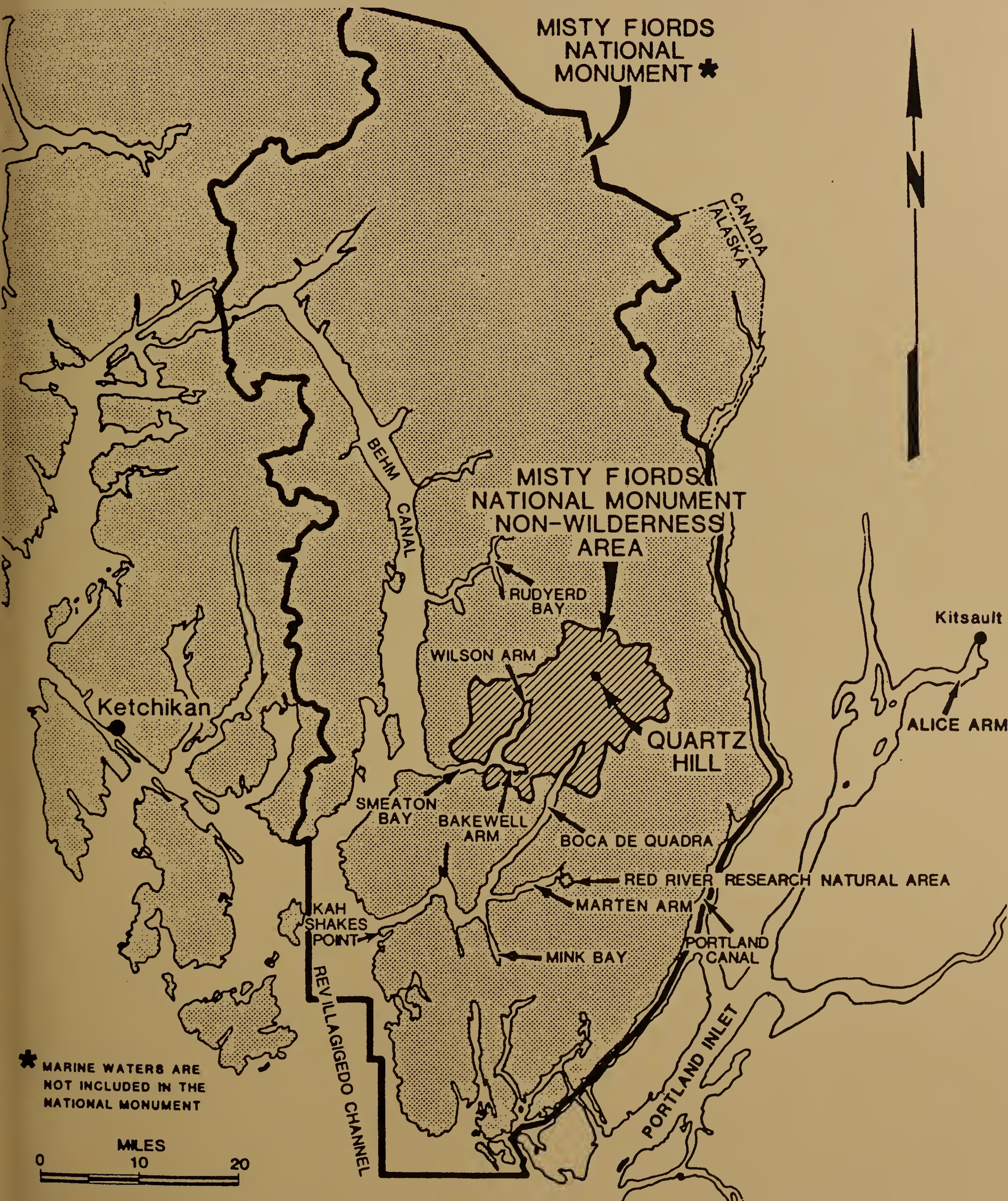
1.0
PURPOSE AND NEED FOR ACTION



1.0 PURPOSE AND NEED FOR ACTION

1.1 PURPOSE AND NEED FOR THE PROPOSED ACTION

An Environmental Impact Statement describes, for public review and consideration, a proposed federal action that could significantly affect the human environment. This obligation is an intrinsic element of the National Environmental Policy Act (NEPA) of 1969, clarified in regulations of the Council on Environmental Quality (CEQ) and those governing the jurisdiction and authority of the various federal agencies.

This Final Environmental Impact Statement, hereafter referred to as the EIS, was prepared by the U.S. Department of Agriculture, Forest Service, Tongass National Forest. This EIS and comments on it by interested parties will be used by the Forest Service; the U.S. Army Corps of Engineers, Alaska District (Corps); and the U.S. Environmental Protection Agency, Region X (EPA) in their decision-making processes related to the proposed issuance of the permits required for this project.

The Forest Service has received an Operating Plan for development of the Quartz Hill molybdenum project from United States Borax & Chemical Corporation, acting on behalf of its affiliate, Pacific Coast Molybdenum Company, the owner of the Quartz Hill property. The project site is located in Misty Fiords National Monument, approximately 45 miles east of Ketchikan, Alaska. The Operating Plan is for an open pit mine, a processing plant, and associated facilities needed to produce molybdenum disulfide from U.S. Borax's patented mining claims at Quartz Hill. U.S. Borax has stated in its Operating Plan that the project will require special use permits and/or leases for use of surface area in the National Forest. The Forest Service may issue special use permits and leases for this project under the authority of Title V and Title XI, respectively, of the Alaska National Interest Lands Conservation Act (ANILCA). Section 505(b)(3) of ANILCA provides that the Plan of Operations include provisions which are adequate for the purposes of:

1. Preventing significant adverse environmental impacts to the fishery habitat (including but not limited to water quality and water quantity) or other fishery values; and

2. Maintaining present and continued productivity of the habitat of anadromous fish and other foodfish which might be affected by the mining and other activities proposed to be conducted in accordance with such plan or such stages of the plan of operations.

All aspects of the proposed operations, as they affect National Forest surface resources, are subject to Operating Plan (36 CFR 228) or special use permit (36 CFR 251) approval by the Forest Service. The Forest Service has determined that these approvals would be a major federal action and has decided that an EIS must be prepared pursuant to

36 CFR 228.5. The federal action considered in the EIS is the approval by the Forest Service of an Operating Plan including the special use permits and/or leases for the proposed project and the imposing of reasonable environmental mitigation requirements. The Forest Service response may be to approve the Operating Plan as proposed or to require modification of the plan.

The project would require other major federal permits from the Corps and the EPA. The evaluation of the project impacts associated with these permits was included in the determination of the environmental consequences of the proposed project and alternatives in this EIS. The official responsible for issuing or denying the permits for the Corps action will be the District Engineer, Alaska District. The Regional Administrator, Region X, will be the official responsible for the EPA action on the proposed permits under its jurisdiction. If their concerns are satisfied by the document, the Corps and the EPA intend to adopt this EIS as part of their decision-making processes.

The Corps has jurisdiction over this action under Section 10 of the Rivers and Harbors Act of 1899, which provides for the regulation of the construction of structures or work in or affecting navigable waters of the United States; and under Section 404 of the Clean Water Act, which provides for regulation of the discharge of dredged or fill material in waters of the United States, including wetlands. Action by the Corps could be issuance or denial of the permits, issuance of the permits with conditions, and/or permitting other alternatives.

The discharge of mill tailings to marine waters requires a National Pollutant Discharge Elimination System (NPDES) permit from the EPA in accordance with the Clean Water Act. The EPA will review the permit application to ensure compliance with the regulatory requirements of Section 402 of the Clean Water Act. In the review of the NPDES permit application, the EPA applies criteria related to ocean discharges. If the receiving waters being considered for tailings disposal were considered territorial seas, the EPA would be required to prepare an Ocean Discharge Criteria Evaluation (ODCE) in accordance with the requirements of Section 403(c) of the Clean Water Act. The Department of State, however, established closure lines at the entrance of Smeaton Bay and Boca de Quadra in 1986. Both fjords are now considered internal waters of the State of Alaska, and the EPA is not required to prepare an ODCE. Instead, the EPA has used the Ocean Discharge Criteria (40 CFR Part 125, Subpart M) as a means to complete an environmental evaluation of estuarine and marine impacts using Best Professional Judgment (BPJ). The BPJ analysis is included in this EIS as Appendix S. Information appearing in Appendix S and elsewhere in the EIS was shared. In the event of tailings advection into Behm Canal, which is part of the territorial seas, the BPJ suffices for an ODCE of the material advected out of Smeaton Bay.

The Ocean Discharge Criteria guidelines used by the EPA in its evaluation specify the criteria for evaluating the biological effects of the discharge of pollutants. The evaluation includes examinations of the location of the discharge, including the composition of the

biological community and existence of special aquatic sites; the nature of the pollutants to be discharged, including their quantities, composition, potential for bioaccumulation, persistence, and transport; and the effect on human health. The guidelines also address the economic and social effects of the discharge, such as the impacts on fishing, recreation, or other economic or social values.

1.2 BACKGROUND OF THE PROJECT

In 1971, U.S. Borax initiated a geochemical exploration program in Tongass National Forest in southeastern Alaska that resulted in the discovery of a significant molybdenum deposit. The area of the mineral deposit has been named Quartz Hill. The discovery led to the acquisition of rights to this mineral deposit by the location of mining claims under the federal mining laws. In 1974, the exploration phase of the project was initiated. Some environmental baseline data collection programs were initiated in 1975; however, most began in 1978.

In 1976, U.S. Borax applied to the Forest Service for a special use permit to construct a surface access road to the ore body. The purpose of the road was to allow extraction of a sufficient quantity of ore to verify the extent and quality of the deposit, as well as to evaluate potential mining and milling processes; this is known as the bulk sampling phase. An EIS (Forest Service 1977a and 1977b) was prepared by the Forest Service on this application. The record of decision based on the 1977 EIS recommended that surface access be limited to a route in the Keta River drainage and resulted in the issuance of a special use permit. This decision was appealed by a private organization which contended that helicopter access was adequate and would remove the need for a road. This appeal was upheld and the permit denied on December 5, 1978. On the same day, the Quartz Hill area was declared part of Misty Fiords National Monument. ANILCA (Public Law 96-487) became law on December 2, 1980 and designated the Misty Fiords area as a National Monument. ANILCA placed all of the Monument in wilderness classification with the exception of 152,610 acres in the Quartz Hill area which was classified non-wilderness to allow for development of the project.

ANILCA specified timetables and requirements for documents and decisions related to the Quartz Hill project. The two documents required are the Mining Development Concept Analysis Document (CAD) and the EIS for the surface access road and the bulk sampling phase. The CAD was issued in draft form in June 1981 and finalized in September 1981 (Forest Service 1981a). In accordance with Section 503(h)(2) of ANILCA, the CAD addresses concepts under consideration for mine development, general foreseeable potential environmental impacts of each concept and the studies needed to evaluate and address the impacts, and likely surface access needs and routes for each concept. The road access and bulk sampling EIS used the CAD as background for analysis of impacts and potential mitigation measures associated with access and bulk sampling. The Final EIS for these activities was issued in July 1982 (Forest Service 1982a) and addressed the issues

required in Section 503(h)(3) of ANILCA. The primary alternatives evaluated in the EIS were no action, helicopter access, and construction of marine facilities and access road in either the Blossom or Keta river valleys as needed for bulk sampling. The preferred alternative as identified in the EIS was for bulk sampling surface access via the Blossom River route.

The Forest Service granted a special use permit for the bulk sampling access road. The Corps authorized construction of portions of the road that are within its jurisdiction, as well as a wharf after completion of the Road Access and Bulk Sampling EIS. This road and wharf are now complete, have been accepted by the Forest Service, and are in use. An EIS for U.S. Borax's 1980-1983 Plan of Operation, Amendments 2, 3, and 4 was completed by the Forest Service in April 1983 (Forest Service 1983a).

The Quartz Hill project would supply molybdenum to U.S. and free world markets. Unlike most other minerals, the U.S. production of molybdenum has historically been sufficient to satisfy domestic needs and provide supplies for export. In 1982, a year in which the economy and molybdenum markets were depressed, the estimated U.S. demand was 33 million pounds of molybdenum, while U.S. production was 75 million pounds (Bureau of Mines 1982). In 1979, when molybdenum demand was at its peak to date, domestic U.S. demand was 73.7 million pounds, while U.S. production was 144.0 million pounds (Bureau of Mines 1982). Total free world production during these years was 202.2 and 157.0 million pounds in 1979 and 1982, respectively (Bureau of Mines 1982). At an 80,000 tpd ore processing rate, the Quartz Hill project would have produced approximately 63 percent and 141 percent of U.S. demand in 1979 and 1982, respectively. This would be approximately 32 percent in 1979 and 62 percent in 1982 of U.S. production and 23 percent in 1979 and 30 percent in 1982 of free world production.

A Draft EIS was published in 1984 addressing the environmental impacts of the construction, operation, and postmining abandonment of a mine, mill, and associated facilities at the Quartz Hill site as specified in the Road Access and Bulk Sampling EIS (Forest Service 1982a). It evaluated all reasonable alternatives as required by NEPA and CEQ guidelines.

After the Draft EIS was published, a number of changes were made in the project and additional data became available. Additional water supply alternatives were considered in response to comments on the DEIS; the transmission line power supply alternative was dropped; and the disposal of tailings in Wilson Arm/Smeaton Bay became part of the proposed project. Several studies were completed too late to be considered in the DEIS, including the instream flow analysis of the Wilson River and Tunnel Creek, pilot plant studies, some oceanographic modeling, chronic toxicity bioassay tests, and waste rock acid producing potential tests. Additional information and analyses relating to tailings disposal in Wilson Arm/Smeaton Bay also became available. As a result of the changes and the new data, the Forest Service decided that a revised draft EIS (RDEIS) would be required.

Since issuance of the RDEIS, a number of other changes have been made in the project. The well field on the Wilson River has been deleted and replaced by a supplemental water source intake on the Blossom River. The weir on the Blossom River has also been eliminated from the design. The log transfer facility at the Wilson Arm floating camp has been deleted from the U.S. Army Corps of Engineers Public Notice (see EIS Appendix P). If the log transfer facility is later deemed necessary, it will be the subject of a separate permitting procedure for log transfer facilities in Alaska, executed jointly by the Corps and EPA.

As with the DEIS and the RDEIS, the FEIS was prepared by Envirosphere Company, a third party contractor, under the direction of the Forest Service. The Forest Service directed the consultant on all phases of the EIS and has final responsibility for its scope and content. U.S. Borax assumed financial responsibility for the preparation of the EIS under the terms of a Memorandum of Understanding (MOU) with the Forest Service.

1.3 SCOPING AND PUBLIC INVOLVEMENT

As required by the final regulations implementing the National Environmental Policy Act (NEPA), the Forest Service has provided for an early and open process to determine the scope of issues to be addressed and to identify the significant issues related to the proposed project. The Forest Service accomplished this in two principal ways: by forming an interdisciplinary team (IDT) from public agencies and U.S. Borax to identify issues, and by holding a public scoping meeting.

The IDT has been formed by the Forest Service under its guidelines for compliance with NEPA regulations. One of the primary purposes of the IDT is to establish the scope of the EIS. The IDT is chaired by Mr. E.R. Johnson of the Forest Service. Its members are comprised mostly of representatives of all federal cooperating agencies and officials of Alaska and federal agencies which have jurisdiction or responsibility for maintaining the environmental quality or managing the natural resources of the Quartz Hill area. Agencies represented on the IDT include Alaska Department of Fish and Game, Alaska Department of Community and Regional Affairs, Alaska Department of Environmental Conservation, Alaska Department of Commerce and Economic Development, Alaska Department of Transportation and Public Facilities, Alaska Department of Natural Resources, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Bureau of Mines, National Marine Fisheries Service, and U.S.D.A. Forest Service. Also included are members from U.S. Borax, the proponent of mine operations, and representatives of the Ketchikan Gateway Borough and Southern Southeast Regional Aquaculture Association. The project manager from Envirosphere, who has directed the preparation of the EIS, participates in the IDT meetings.

As part of its scoping process, the Forest Service invited participation from other government groups, organizations, and individuals at a Public Scoping Meeting on January 19, 1983 in Ketchikan. Descriptions of the EIS process and of the proposed project were provided by the Forest Service and U.S. Borax, respectively. The floor was then opened to members of the public who voiced their concerns regarding the planned development at Quartz Hill. The comments were recorded on tape. Members of the public wishing to submit written comments on scoping and issues were requested to do so before February 23, 1983. All written and oral presentations were considered and incorporated into a list of significant issues.

The IDT met on January 19 and 20, 1983 in Ketchikan to discuss scoping issues for the EIS. A preliminary listing of potential issues was discussed at this meeting. At the meeting the Forest Service requested a formal submittal of comments and issue discussions by any agencies concerned about the project. Agencies were given until February 23 to submit comments. The IDT met again on March 1-3, 1983 in Ketchikan to define specifically the scope of the EIS. The IDT discussed a revised list of issues which reflected the issues raised by IDT and the public in oral and written comments. Based on these discussions, a significant issues document was finalized. Significant issues identified include:

- Impacts of project water supply on area water courses
- Tailings disposal impacts
- Fisheries habitat protection
- Worker housing and possible impacts to Ketchikan
- Water quality protection
- Impacts of project activities on wildlife and wildlife habitats
- Protection of adjacent wilderness area values

The complete significant issues document is presented in Appendix B of this EIS. It identifies issues, types of potential impacts, the significance of each impact, and comments on impact analysis methods and impact criteria.

The notice of availability of the DEIS was published in July 1984. Copies of the Draft EIS were sent to many agencies and individuals (see Chapter 8.0) inviting comments. Public comments were also solicited, and a public workshop and a public meeting were held on September 6, 1984 in Ketchikan. Written comments were received until October 5, 1984. During the public comment period, 137 comments were received. The public meeting served as an official public review vehicle for EPA and the Corps as well as the Forest Service. The public interest review process of the Corps for the work within their jurisdiction is concurrent with this EIS.

A few major issues were raised during the public comment period, and they comprised the main reasons for issuance of the RDEIS. Commentors were concerned with the potential impacts on salmon from the Wilson River well field as a water supply source during low-flow periods, particularly since the instream flow study was not available for

evaluation in the DEIS. They also requested that additional water supply alternatives be evaluated. After the DEIS was produced, the project proponent changed the proposed project to propose tailings disposal in Wilson Arm/Smeaton Bay and made new information available that was important in evaluating that proposal. These concerns, coupled with the need to evaluate several studies completed after the DEIS was produced, were the main issues in the RDEIS.

Comments on the RDEIS focused on several issues. Chief among them were the factors that together determine the impact of tailings disposal on salmon and other marine organisms. The factors at issue included the physical behavior of tailings after being deposited in a fjord; the chemical constituents, including toxic metals, of the tailings; the chemical behavior of the tailings in the fjord; and the availability of toxic elements to marine biota. Because the Forest Service and the EPA interpreted model results and data differently, the two agencies reached different conclusions concerning the preferred tailings disposal alternative: the Forest Service preferred Wilson Arm/Smeaton Bay, while the EPA preferred Boca de Quadra. Both agencies have reached agreement in this EIS that the risks of exceeding water quality criteria and the risks to marine life in either fjord are sufficiently small that tailings disposal can be permitted at either location.

Other issues on which commentors focused include the mitigation and monitoring plans, which many deemed inadequate; the relationship of the Quartz Hill project with the proposed southeast Alaska transmission intertie; and the fisheries impacts associated with the Wilson River well field and the Blossom River weir. These and other issues have all been addressed in this EIS.

1.4 OTHER PERMITS AND APPROVALS REQUIRED

U.S. Borax will have to obtain numerous permits and approvals from federal and state agencies in order to develop the Quartz Hill project. A preliminary list of the major permits and approvals necessary is presented in Table 1-1. Additional permits may be required during the life of the project.

1.5 ORGANIZATION OF THE EIS

This EIS is organized according to the format prescribed by the NEPA regulations. The chapter headings are descriptive to aid the reader in locating specific topics of discussion by using the table of contents. Chapter 2.0 describes and compares the proposed project and the alternatives. Chapter 3.0 describes the environment affected by the project, but does not attempt to provide a baseline description of all existing environmental conditions. Chapter 4.0 describes the environmental impacts and mitigation measures. The technical

TABLE 1-1

PRELIMINARY LIST OF REQUIRED PERMITS AND APPROVALS FOR QUARTZ HILL MOLYBDENUM PROJECT[1/]

Permit or Approval	Applicability
FEDERAL	
FOREST SERVICE	
Environmental Impact Statement and Record of Decision	Entire project development, as presented in the Plan of Operations
Plan of Operations	Any mining development activity that causes significant surface disturbance; excludes any patented mining claims unless activity affects federal lands
Special Use Permit	Use or construction of facilities on National Forest land; excludes area of mining claims
Mineral Material Permit	Use of mineral materials (borrow materials) taken from National Forest land
Timber Sale Contract	Value of timber removed from National Forest land
Utility Corridor Approval	Pipelines, transmission lines, or other facilities that may be constructed in a wilderness area
Antiquities Permit	Preconstruction cultural resources survey of project area
ARMY CORPS OF ENGINEERS	
Department of the Army Permit	Discharge of dredged or fill material in tidelands, streams, or adjacent wetlands; structures within navigable waterways

1/ More than one permit or approval may be required for each category, e.g., one for each major facility, activity, or site.

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TABLE 1-1 (Continued)

Permit or Approval	Applicability
DEPARTMENT OF ENERGY	
Authorization to Import Electricity	Transmission line, if one were constructed and it crossed international boundaries
Presidential Permit	Transmission line, if one were constructed and it crossed international boundaries
COAST GUARD	
Permit to Handle Hazardous Materials	Vessels or waterfront facilities handling, storing, loading, discharging, and transporting hazardous materials
Application for Private Aids to Navigation	Navigation aids required or authorized by the Coast Guard
FEDERAL AVIATION ADMINISTRATION	
Notice of Landing Area Proposal	Seaplane bases and heliports
Determination of No Hazard	Structures such as stacks, antennas, transmission lines, and buildings that may be a hazard to air navigation
FEDERAL COMMUNICATIONS COMMISSION	
Radio and Microwave Station Authorizations	Land mobile radio service and operational fixed microwave service
ENVIRONMENTAL PROTECTION AGENCY	
National Pollutant Discharge Elimination System Permit	Point-source wastewater discharges including mine drainage, construction effluents, mill process effluent, mill tailings, and sewage effluent
Spill Prevention, Containment, and Countermeasures Plan	Onshore and offshore oil storage facilities such as tank farm at wharf, power plant, and construction staging areas

TABLE 1-1 (Continued)

Permit or Approval	Applicability
ENVIRONMENTAL PROTECTION AGENCY (Continued)	
Notification of Hazardous Waste Activity	Covers on-site generation and transportation of hazardous wastes
DEPARTMENT OF LABOR	
Legal Identity Report	Registration of surface and underground mining facilities
Training Plan Approval	Training of surface and underground miners
STATE	
OFFICE OF THE GOVERNOR	
Coastal Management Program Certification	Certification of consistency of proposed activities with the Alaska Coastal Management Program
DEPARTMENT OF ENVIRONMENTAL CONSERVATION	
Prevention of Significiant Deterioration Permit	All significant emissions of air pollutants associated with project development
Certificate of Reasonable Assurance	Certification that discharges to be authorized by federal permits will comply with state water quality standards
Solid Waste Management Permit	Disposal of solid wastes such as garbage, sludges, incinerator ash, mine wastes, spoils, and overburden
Air Quality Permit to Operate	All significant emissions of air pollutants associated with project development
Oil Facilities Approval of Financial Responsibility	Operation of oil terminals, oil barges, and tank vessels at the wharf site

TABLE 1-1 (Continued)

Permit or Approval	Applicability
DEPARTMENT OF ENVIRONMENTAL CONSERVATION (Continued)	
Oil Facilities Discharge Contingency Plan	Oil storage facilities such as tank farm at the wharf, power plant, and construction staging areas
Water and Sewer Plan Approval	Plans for water supplies and sewage treatment and disposal at construction camps and permanent facilities at the mine, processing facilities, wharf, and townsite
Food Service Permit	Food service operations at construction and permanent facilities
DEPARTMENT OF NATURAL RESOURCES	
Land Use Permit	Temporary use of state land including access to and location of temporary construction facilities
Tidelands Lease	Any project facilities such as wharf, tank farm, and tailings outfall, to be located on tidelands
Right-of-Way Easement	Permanent project facilities crossing state tidelands
Water Rights Permits	Temporary and permanent use of water for potable and process purposes
Permit to Construct or Modify a Dam	Sedimentation dams for mine drainage and a water supply reservoir on Tunnel Creek (or alternative sites)
DEPARTMENT OF FISH AND GAME	
Anadromous Fish Protection Permit	Construction of project facilities that will affect the flow or bed of a specified anadromous fish stream

TABLE 1-1 (Continued)

Permit or Approval	Applicability
DEPARTMENT OF PUBLIC SAFETY	
Life and Fire Safety Plan Check	All occupied buildings and facilities for compliance with state fire regulations
DEPARTMENT OF LABOR	
Fired and Unfired Pressure Vessel Certificate	Postconstruction inspection of pressure vessels
Elevator Certificate of Operation	Inspection of elevators in buildings occupied by employees
DEPARTMENT OF EDUCATION	
School Construction Approval	Townsite, only if a school is constructed
DEPARTMENT OF HEALTH AND SOCIAL SERVICES	
Certificate of Need	Townsite, only if health care facilities are constructed
Health Care Facilities Construction License	Townsite, only if health care facilities are constructed
DEPARTMENT OF REVENUE	
Affidavit for Non-Resident Business Taxation	To be determined
Alaska Business License	Required to conduct business in Alaska
Alaska Mining License	Required to conduct mining operations in Alaska

Source: U.S. Borax 1983a with modifications.

appendices (C through N) primarily support Chapters 3.0 and 4.0. They include calculations, methods, additional data, and details that support conclusions. A more detailed description of the project and the alternative concepts is presented in Appendix A. A complete list of the significant issues identified in the scoping process is given in Appendix B. As additional aids to the reader, a glossary, a list of abbreviations, an index, and a guide to location of the items required for the Corps' evaluation of the 404(b)(1) requirements (Appendix O) are included. The Corps' public notice is included in Appendix P of this EIS. Appendices A through P are bound together as Volume 2, accompanying the body of the EIS (Volume 1).

Letters commenting on the RDEIS are found in Appendix Q and responses to those comments are found in Appendix R. EPA's Best Professional Judgment report constitutes Appendix S. Appendices Q, R, and S make up Volume 3.

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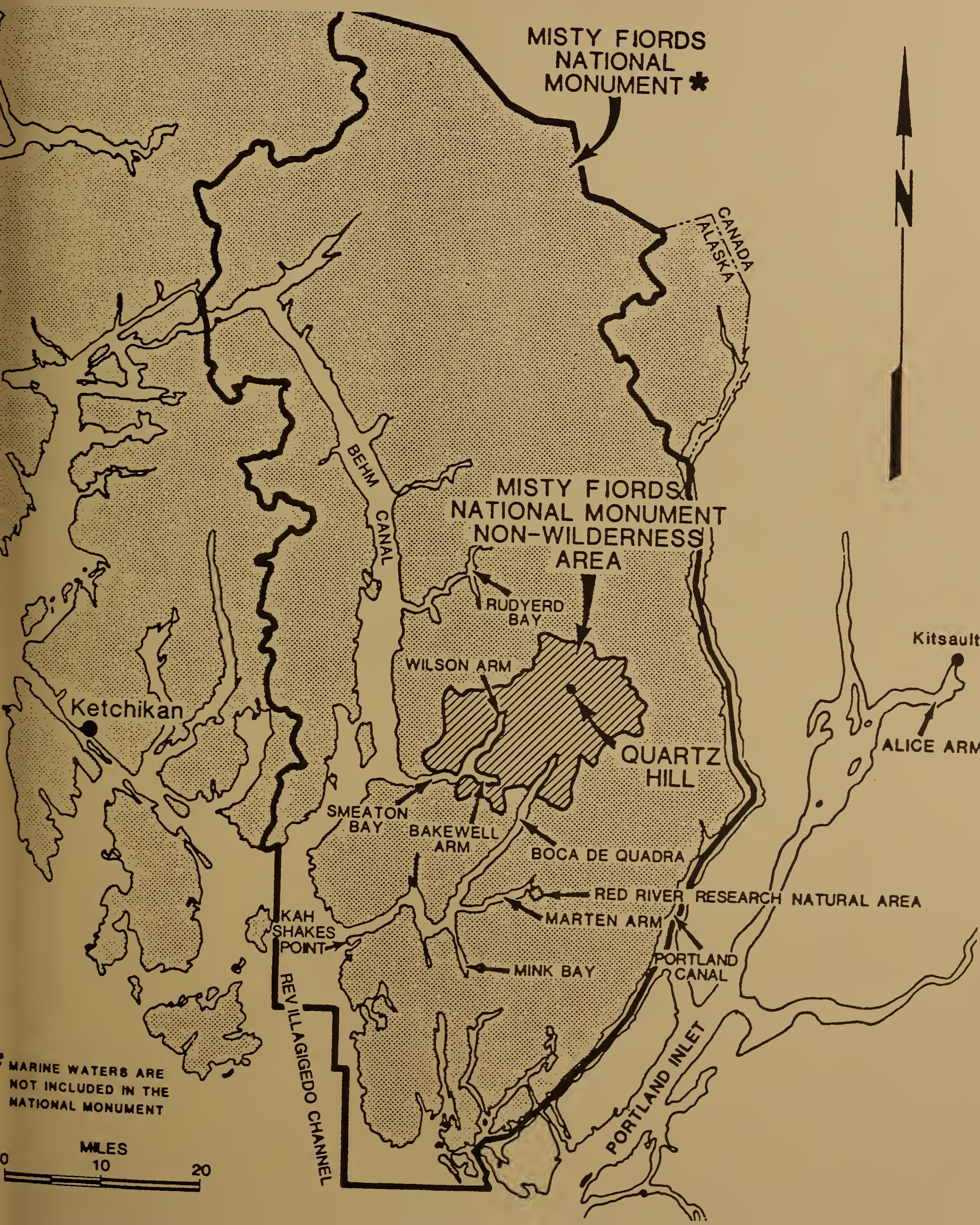
2.0
ALTERNATIVES INCLUDING THE PROPOSED PROJECT



2.0 ALTERNATIVES INCLUDING THE PROPOSED PROJECT

2.1 FORMULATION OF ALTERNATIVES

This chapter describes several project "concepts" for the development of the molybdenum deposit at Quartz Hill. These project concepts include U.S. Borax's proposed project and several reasonable alternatives, including the no action alternative. Each of these project concepts consists of several project "components" including the mine site facilities, crusher, ore transport, mill, tailings disposal, and housing needed to develop a complete project. The no action alternative was also studied in detail.

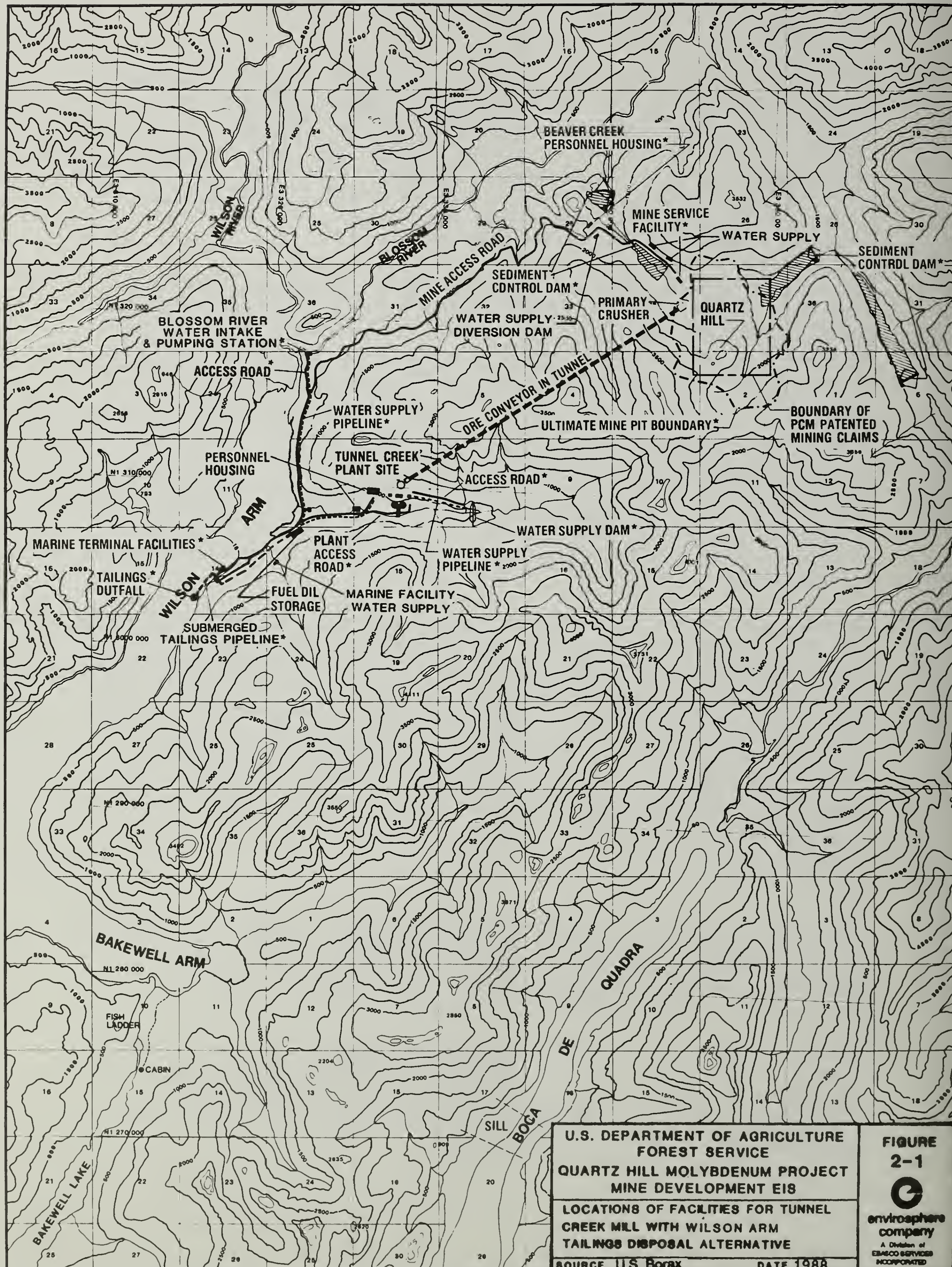
The project concepts were developed by combining project components. In several cases certain project components are incompatible with other project components and, therefore, could not be combined to produce a reasonable project concept. For instance, since the on-land tailings disposal component involves a tailings impoundment in Tunnel Creek that would inundate the area needed for the Tunnel Creek mill site component, there is no reasonable project concept that incorporates the Tunnel Creek mill site with on-land tailings disposal. Proposed and alternative components incorporated into one or more project concepts for detailed study in the EIS are described briefly in this section and described fully in the Project Description, Appendix A. Several other alternative components that have been considered, but have been eliminated from detailed study, are also described in this section and in Appendix A.

The proposed project is described below. In the subsequent sections of this EIS, the proposed project is referred to as the "Tunnel Creek Mill with Wilson Arm tailings disposal alternative." The tailings disposal location for this proposed project is different than the location that was in the proposed project in the Draft EIS. In Chapter 4.0 of the DEIS, the impacts of all the alternative concepts were assessed with reference to tailings disposal in the Boca de Quadra inner basin. Rather than completely rewrite the chapter, the Boca de Quadra inner basin was also used as the discharge point of reference for Chapter 4.0 of the RDEIS and this FEIS.

2.2 PROPOSED PROJECT

The proposed project is the development of a nominal 80,000 ton per day (tpd) molybdenum mine and mill at the Quartz Hill site in Misty Fiords National Monument. Figure 2-1 shows the location of the major facilities that are included in the proposed project. Appendix A describes the project facilities in detail.

Proven, probable, and possible minable ore reserves at Quartz Hill are currently estimated at about 1.5 billion tons of ore, with an average grade of 0.14 percent MoS_2 (molybdenum disulfide or molybdenite). The Quartz Hill mine is expected to produce about 1.1 million tons of molybdenum (Mo) over its 55-year life.



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOCATIONS OF FACILITIES FOR TUNNEL CREEK MILL WITH WILSON ARM TAILINGS DISPOSAL ALTERNATIVE

SOURCE U.S. Borax DATE 1988

FIGURE 2-1

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

2.2.1 Mine Site

The ore body would be mined by open pit methods. During the first 3 years of mine development, the preproduction period, work would involve construction of access roads and removal of vegetation and overburden from the area to be developed as the pit. Merchantable timber would be harvested and used on-site or sold to an outside operator. Overburden, including muskeg, unconsolidated alluvium, and glacial till would be stripped from the area in advance of pit development and ore extraction. The muskeg and glacial till would be separated where feasible. Muskeg and mixed muskeg and glacial till would be disposed of in the waste rock disposal area with other waste rock. In areas where glacial till is deep, muskeg and glacial till would be separated, with the glacial till being stockpiled for future use as topsoil. Since there would be more glacial till than required for reclamation, the excess would be placed in the waste rock disposal areas.

Production from the open pit would begin at a nominal rate of 40,000 tpd. After 4 to 6 years the mining rate would be expanded to a nominal rate of 80,000 tpd. Actual production rates could vary by 10 to 15 percent above or below the nominal rate. Mining would be accomplished in five steps: drilling, blasting, loading, hauling, and dumping. After drilling and blasting, the fragmented rock would be loaded by power shovels into 170 ton dump trucks. Ore would be hauled to the crusher for further processing. Waste rock would be hauled to a waste rock dump. The open pit would ultimately have maximum dimensions of 2.0 miles (mi) long and 1.3 mi wide. Mining in the open pit would continuously widen and deepen the generally elliptical pit. The northern portion of the ore body, lying at surface elevations of 1,800 to 1,900 ft, is referred to as Bear Meadow. The southern portion of the ore body, lying at elevation 2,700 ft is referred to as Quartz Hill. The pit would occupy approximately 1,040 acres (ac) and have a final depth ranging from 1,325 to 1,875 ft. Approximately 2,000 additional acres would be disturbed by access roads, the mine service area, waste rock disposal, and water quality control facilities. Water would enter the pit from precipitation, runoff from uphill areas, and groundwater discharges through the pit's exposed faces and floor. The mine area would be free draining from the preproduction phase through approximately the first 6 years of operation. After that, pumping would be required to remove water from the pit.

Waste rock would be deposited in the valleys of Beaver Creek, White Creek, and Hill Creek, and the waste rock areas would also receive overburden, noncommercial timber, grubbed material, slash, stumps, and other organic debris. Waste rock areas would be developed in lifts, with a maximum depth of waste rock of approximately 900 ft in some locations. Surface runoff from undisturbed areas upstream of the waste rock disposal area would flow through the coarser rock at the bottom of the waste piles to the downstream sedimentation ponds.

Long-term control of the portion of the waste rock that has the potential to produce acidic mine drainage would be planned in conjunction with normal mine planning. The plan would be implemented when development of the ore body begins and would continue through the

life of the mine. The plan would use several proven methods and would incorporate new methods as they are developed either on-site or at similar mines. Potentially acid-producing rock would be identified through analyses of blasting drill hole materials and field observations. Control of acid-producing rock would be accomplished by several alternate methods as appropriate, including variable fragmentation of waste rock, blending of acid-producing and acid-consuming materials, segregation or isolation, and reducing the permeability of the waste rock disposal area to air and water. If these methods are found to be inadequate, chemical treatments will be used.

The mine service area, including maintenance areas, truck parking, and fuel, explosive, and lubricant storage, would be located about 1,500 ft north of the crusher and would occupy about 30 ac. It would be connected to the crusher and mine pit by a 150-ft-wide access road.

Water from mine pit dewatering and runoff from the waste rock disposal area and mine service area would be routed to water quality control ponds. Before the start of surface disturbances, interim water quality control structures would be constructed in upper Beaver Creek and in White Creek. As the waste rock areas expand, permanent water quality control structures would be constructed on Hill Creek and lower Beaver Creek. These ponds are intended to control suspended solids in runoff from the disturbed areas and would be designed to treat the volume equivalent to runoff from a 10-year, 24-hour storm event plus provide storage for accumulated sediment. The sediment ponds would include an outlet works designed to decant water to facilitate compliance with NPDES effluent limitations and ADEC receiving stream water quality standards at the boundaries of the mixing zones. The interim ponds would be carefully monitored not only for compliance, but also to obtain data for design of the permanent ponds.

2.2.2 Crusher

The location of the crusher would be at the northwestern edge of the open pit. The crusher facility would include the crusher building and a maneuvering area for the trucks delivering ore. Approximately 5 ac would be required for this facility. Ore hauled from the mine would be dumped into the crusher where it would be broken into smaller pieces. Dust control would be provided. The crushed ore would be fed to the belt conveyor for transport to the mill.

2.2.3 Ore Transport

Crushed ore would be conveyed from the crusher to the coarse ore stockpile at the mill site at Tunnel Creek via a 22,000-ft-long tunnel. Tunnel construction and excavation would remove approximately 225,000 cubic yards (cu yd) (natural volume before bulking) of waste rock. The tunnel would likely be constructed by crews working from the Tunnel Creek end. Waste from the Tunnel Creek end would be used for foundation material in the mill area to the extent possible, with any excess disposed in a waste rock disposal area. Groundwater inflow and

runoff from tunnel construction areas would be routed to small sedimentation ponds near the tunnel portals in Tunnel Creek designed specifically to handle these flows.

During operation of the tunnel, a belt conveyor would transport the crushed ore. The conveyor system is designed to generate approximately 1 MW of power at a processing rate of 80,000 tpd by utilizing the downhill movement of the ore.

2.2.4 Tunnel Creek Processing Facilities

The processing facilities would be located on the north side of Tunnel Creek. Processing would consist of grinding, flotation, thickening, filtration, and shipment. This processing, which physically separates the molybdenite particles from the host rock, would produce two major output streams: one, referred to as concentrate, is predominantly molybdenite mineral particles; the other, referred to as tailings, is a waste slurry containing host rock particles. An average of about 2.8 pounds (lbs) of molybdenite is produced for every ton of ore processed.

After access road construction and site preparation are complete, the mill would be constructed using large prefabricated modules up to 60 ft wide, delivered to the wharf and hauled up the access road. Site facilities would include a coarse ore storage area near the conveyor tunnel portal; a large building containing grinding mills, flotation tanks, and filtration units; a reagent storage area; two tailings thickeners; a parking, service, and open storage yard; water storage tanks; and a runoff retention pond. The power plant, fuel storage, and incinerator would also be located adjacent to the mill. These facilities would occupy about 210 ac. The offices, shop, and housing facilities would also be located in the Tunnel Creek valley west of the mill, and a water reservoir would be up the valley to the east.

From the conveyor tunnel, the belt conveyor would discharge to an uncovered coarse ore stockpile at the mill site. Ore would be transferred to a grinding unit where it would be reduced to a size small enough that discrete particles would be predominantly either molybdenite or host rock. Grinding would be accomplished as a wet process. Grinding is followed by flotation, where chemical reagents, added to a slurry of finely ground ore and water, promote separation of the concentrate and tailings. Molybdenite concentrate would be dewatered and placed in containers for shipment to market or a refinery at Grays Harbor, Washington. Tailings would be sent to thickeners where some water would be reclaimed for reuse in the process. Tailings would then be routed to the tailings disposal facilities.

2.2.5 Wilson Arm Marine Tailings Disposal Facilities

Tailings would be transported from the Tunnel Creek mill site through a pipeline to Wilson Arm. Two pipelines would be installed from the mill site to the Wilson Arm wharf. The pipeline route would follow and be an extension in width of the main access road to the wharf. The pipeline would be protected from avalanches as necessary. Spill containment would be provided by a ditch paralleling the line, which

would drain to an emergency retention basin. The pipelines would transport the tailings slurry by gravity flow. The tailings would be discharged into Wilson Arm at a depth of approximately 150 ft.

A seawater mixing box and entrained air eliminator would be constructed near the outlet to provide for density adjustment of the tailings. The tailings and fresh water would be mixed with seawater to adjust the slurry density to minimize turbulence that might interfere with the settling of the tailings. Seawater would be drawn from a depth of about 120 ft below the surface. Approximately 79,850 tpd of tailings would be discharged to Wilson Arm when the processing rate is 80,000 tpd. The tailings would leave the thickener at 40-50 percent by weight solids. At 45 percent by weight solids, this would be 16,600 gallons per minute (gpm) of water. Seawater would be drawn into the submerged mixing box at a rate of 1 to 4 times the weight of the total tailings stream (i.e., 33,000-132,000 gpm).

2.2.6 Housing Facilities

During construction and operation of the project, housing facilities would be provided at the project site. During the preproduction period, the peak workforce would be 1,270. During the period when expansion to 80,000 tpd occurs, the peak workforce would be 1,130. Within the first 20 years of mining the permanent workforce is estimated to reach 1,020.

During the construction phase personnel would be housed at the project site on a full-time basis. Workers would be transported to Ketchikan by ferry and floatplane for vacations and work breaks. Construction camps would be of two types, floating camps and land-based camps. Initially a 200 to 250 person floating construction camp would be located at the Wilson Arm wharf. The floating camp would be self-contained, with no land-based facilities except for small water supplies from local drainages and an approved disposal area for incinerated refuse. The Wilson Arm floating camp would be removed as soon as land-based camps are completed near the Tunnel Creek mill site and at Bruce's Nose near the Quartz Hill mine site. The land-based camps would include sleeping quarters, kitchen, dining, and recreation facilities. Sewage treatment facilities would be provided. The Tunnel Creek camp would house 900, while the mine site camp would house 400.

During the production phase, workers would commute on a weekly basis from Ketchikan to the project site, where they would be housed in the camps described above. Workers would be transported by high speed ferries. Work schedules would be 7 days on, 7 days off, with 12-hour shifts for hourly employees and a 40-hour, 5-day work week for salaried employees. Docking at Ketchikan would be either at leased, existing facilities or at new docks constructed for the project.

2.2.7 Other Support Facilities

Wharf facilities at the present site on Wilson Arm would be expanded southward to provide necessary facilities. The wharf would be the key access point for incoming and outgoing materials during both construction and operation. The wharf would occupy approximately 10 ac

and extend along about 2,500 ft of shoreline. The wharf facilities would include a warehouse, offices, receiving facilities, docking facilities, tanker unloading facilities for fuel oil, fuel storage tanks, and related facilities. Mooring and two submarine pipes and hoses would be provided for a 35,000-dead-weight-ton (dwt) tanker. A sewage treatment plant would handle wastewater from the wharf area. Discharge at the wharf would include pretreated oily water from the oil storage facility and treated sewage, site runoff, and pretreated oily waste from the wharf. In addition to the wharf facilities, tanks for diesel and fuel oil would be located about 3,500 ft north on the uphill side of the mine access road.

Access roads would include the mine development road, which would be doubled in width and would generally follow the alignment of the bulk sample access road, and the mill access road along Tunnel Creek. In addition, an access road of about 0.6 mi would be required from the mine access road to the supplemental water supply facilities on the Blossom River. These facilities would be located just upstream of the confluence of the Blossom and Wilson rivers.

Electrical power would be provided by on-site generation. During construction, power would be provided by diesel-powered generators. An electric power generating station would be constructed near the mill in Tunnel Creek for power supply during project operations. The power plant would be a combined cycle combustion turbine plant with installed capacity of 95 MW. It is estimated that approximately 40 million gallons of oil would be required annually. About 14,500 gpm of chlorinated water would be used for cooling. This water would be recycled for use in the milling process. Power would be transmitted to the mine through the coarse ore conveyor tunnel.

A 52-ft-high earth and rockfill dam with a 530 acre feet (ac ft) reservoir would be constructed on Tunnel Creek to provide water for the mill and power plant. Supplemental water would be pumped from facilities on the Blossom River. Smaller water supplies needed for other project facilities would be developed from local water wells or surface water diversions.

2.2.8 Reclamation Bond

Miners operating on National Forest lands shall, when required by the Forest Service, furnish a bond conditioned upon compliance with reclamation activities. The amount of the bond is based upon the estimated cost of stabilizing, rehabilitating, and reclaiming the area of operations. The amount of the bond may be adjusted to conform with modifications in the plan of operations or accomplishment of portions of required reclamation.

U.S. Borax, on behalf of Pacific Coast Molybdenum, has maintained a bond in varying amounts for many years during the exploration and bulk sampling phases of development. Prior to approval of the mine development plan of operations, the Forest Service will review the existing reclamation bond and require U.S. Borax to furnish additional bonding if necessary, based on the estimated cost to accomplish reclamation.

2.2.9 Reclamation

Operational reclamation would take place during the life of the mine. Areas that would not be used for the following two or more years would be seeded with grass to stabilize them as appropriate. As disturbed areas are abandoned they would be covered with a topsoil mixture and revegetated. Seeding and stabilization of areas that would not be disturbed again would occur as soon as possible within the limits imposed by the seeding and growing seasons.

Post-mining reclamation would be aimed at shaping, stabilizing, and revegetating the disturbed areas to minimize conflicts with natural landforms and to prevent the need for long-term maintenance. Reclamation methodologies would be refined during the project life as reclamation technology advances. Based on present technology, reclamation activities will include the following:

- Vegetate the waste rock disposal areas with native species to control runoff and erosion. The top of the area would be shaped to control infiltration and to provide runoff channels and swales. Glacial till stockpiled from overburden stripping operations would be used as topsoil.

- Stabilize water quality control structures and water supply dams to assure that there would be no catastrophic failures of the dams.

- Remove all mine-related structures such as mine service facilities, employee housing, mill, power plant, access roads, tailings discharge structures, wharf facilities, well fields, utility lines, and peripheral facilities, unless otherwise specified in permits. Equipment would be removed and the areas reshaped and revegetated.

- Permanently close all tunnels. All salvageable equipment and other equipment as necessary would be removed and portal areas would be reshaped and revegetated.

- Reshape and revegetate overburden storage areas.

- Allow the open pit to fill with water. Topsoil application and revegetation for some benches would be performed as the benches are abandoned. Overflow water from the pit would be directed to drainage channels contoured into the surface of the waste rock disposal area.

2.3 DESCRIPTION OF THE ALTERNATIVES

Seven mining project concepts that are reasonable alternatives to the applicant's proposed project have been developed. Major components of each of the reasonable alternative project concepts that are studied in

detail in this EIS are presented in Table 2-1. Figures 2-2 through 2-7 show each of the reasonable alternatives. To understand an overall project concept, the reader should review the description of each individual component listed for that concept. The alternative project component descriptions are included in this section, where they are grouped by component type (Mine Site Facility Alternatives, Crusher Alternatives, etc.). In cases where a project component is identical to that in the applicant's proposed project, the reader should refer to the preceding section for a complete description of that component. The descriptions of the potentially feasible project components provided in this section describe each portion of the project concept alternatives to a level of detail allowing comparison with the applicant's proposed project. The alternatives considered are included so that a full range of reasonable alternatives are addressed in the EIS.

2.3.1 No Action Alternative

The no action alternative would result in no further development of the proposed facilities. However, since U.S. Borax has patented mining claims, they would retain certain rights. The claims are now the private property (both surface and mineral) of U.S. Borax and would not revert to Forest Service ownership. Furthermore, Section 1110(b) of the ANILCA stipulates that adequate and feasible access must be provided to in-holders. Thus, in the no action alternative U.S. Borax would be permitted to leave the bulk sampling access road and wharf in place.

2.3.2 Mine Site Facility Alternatives

The mine site is fixed by the location of the ore body. The options associated with the mine site are the following: (a) the initial and final mining/ milling rates; and (b) sites for disposal of waste rock and overburden materials. Mining/milling rates other than the proposed 80,000 tpd rate are considered to be viable, with the selection of the optimal rate dictated by economics. Only 80,000 tpd is considered in this EIS because it is both the design rate and the maximum rate presently considered to be viable by U.S. Borax. Because of the design of the milling equipment and project economics, a reduction in production during project operations is not feasible.

A temporary shutdown of project operations could occur as a result of unfavorable market conditions. Although it is impossible to accurately predict the likelihood or timing of such a shutdown, a scenario has been developed for the purpose of this EIS. This scenario would involve shutting down the mine and mill from an operating level of 80,000 tpd. The first layoff would reduce the labor force to 300, followed by a second layoff in about one month to a staff of 175. During the shutdown, maintenance would include pit dewatering, some avalanche control as needed, operation of the water quality control facilities, maintenance of the access roads, operation of auxiliary power supply, permit monitoring, and environmental compliance work and

TABLE 2-1

QUARTZ HILL PROJECT ALTERNATIVE CONCEPTS

Concept Title (Figure Showing Concept Features)	Crusher and Ore Transport	Mill	Tailings Transport	Tailings Disposal	Townsite	Power Supply
Proposed Project						
Tunnel Creek Mill with Wilson Arm Tailings Disposal (Figure 2-1)	Crusher at northwest edge of pit and conveyor in tunnel	Tunnel Creek site with one of several alternative water supplies (Tunnel Creek reservoir and Blossom River supplement)	Pipeline along access road to wharf on Wilson Arm, then submerged pipeline to submerged discharge point	Wilson Arm/Smeaton Bay	Commute* or Bakewell or Wilson I or IIa or Phase-In	Power plant at mill
Alternatives						
Tunnel Creek Mill with Boca de Quadra Tailings Disposal (Figure 2-2)	Crusher at northwest edge of pit and conveyor in tunnel	Tunnel Creek site with one of several alternative water supplies	From tailings thickener by launder and/or pipeline in tunnel to submerged discharge point	Inner basin of Boca de Quadra, with possible later extension to middle basin of Boca de Quadra or middle basin only.	Commute or Bakewell or Wilson I or IIa or Phase -In	Power plant at mill
Beaver Creek Mill with Boca de Quadra Tailings Disposal (Figure 2-3)	Crusher at northwest edge of pit and covered conveyor	Beaver Creek site with one of several alternative water supplies	Tunnel and surface pipeline to submerged discharge point	Inner basin of Boca de Quadra with possible later extension to middle basin of Boca de Quadra or middle basin only	Commute or Bakewell or Wilson I or IIa or Phase-In	Power plant at mill or in Tunnel Creek
Beaver Creek Mill with Wilson Arm Tailings Disposal (Figure 2-4)	Crusher at northwest edge of pit and covered conveyor	Beaver Creek site with one of several alternative water supplies	Pipeline along access road to wharf, on Wilson Arm, then submerged pipeline to submerged discharge point	Wilson Arm/Smeaton Bay	Commute or Bakewell or Wilson I or II or Phase-In	Power plant at mill or in Tunnel Creek
Beaver Creek Mill with On-Land Tailings Disposal (Figure 2-5)	Crusher at northwest edge of pit and covered conveyor	Beaver Creek site with one of several water supply alternatives	Pipeline along access road to Tunnel Creek and road to crest of tailings dam. Pipeline along Hill Creek, along Keta River, with one river crossing and up Aronitz Creek	Tailings impounded in Tunnel Creek and Aronitz Creek	Commute or Bakewell or Wilson I or IIa or Phase-In	Power plant at mill

* Proposed project includes commute option.

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TABLE 2-1 (Continued)

Concept Title (Figure Showing Concept Features)	Crusher and Ore Transport	Mill	Tailings Transport	Tailings Disposal	Townsite	Power Supply
North Meadow Mill with Boca de Quadra Tailings Disposal ("Keta Alternative") (Figure 2-6)	Crusher at northeast edge of pit and covered conveyor	North Meadow site mill with one of several water supply alternatives	Pipeline along Hill Creek, down Keta River to Boca de Quadra, then submerged to discharge point	Inner basin of Boca de Quadra with possible later extension to middle basin of Boca de Quadra or middle basin only	Commute or Keta or Phase-In	Power plant at mill
North Meadow Mill with On-Land Tailings Disposal (Figure 2-7)	Crusher at northeast edge of pit and covered conveyor	North Meadow site mill with one of several water supply alternatives	Pipeline along access road to wharf then up Aronitz Creek to impoundment. Pipeline along Beaver Creek and reclaimed Blossom Access Road to Tunnel Creek	Tailings impoundments in Tunnel Creek and Aronitz Creek	Commute or Bakewell or Wilson I or IIa or Keta or Phase-In	Power plant at mill

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U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOCATION OF FACILITIES FOR TUNNEL CREEK MILL WITH BOCA DE QUADRA TAILINGS DISPOSAL AND TOWNSITE ALTERNATIVE

SOURCE ENVIROSPHERE CO. DATE NOV 88

FIGURE 2-2

envirosphere company
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U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

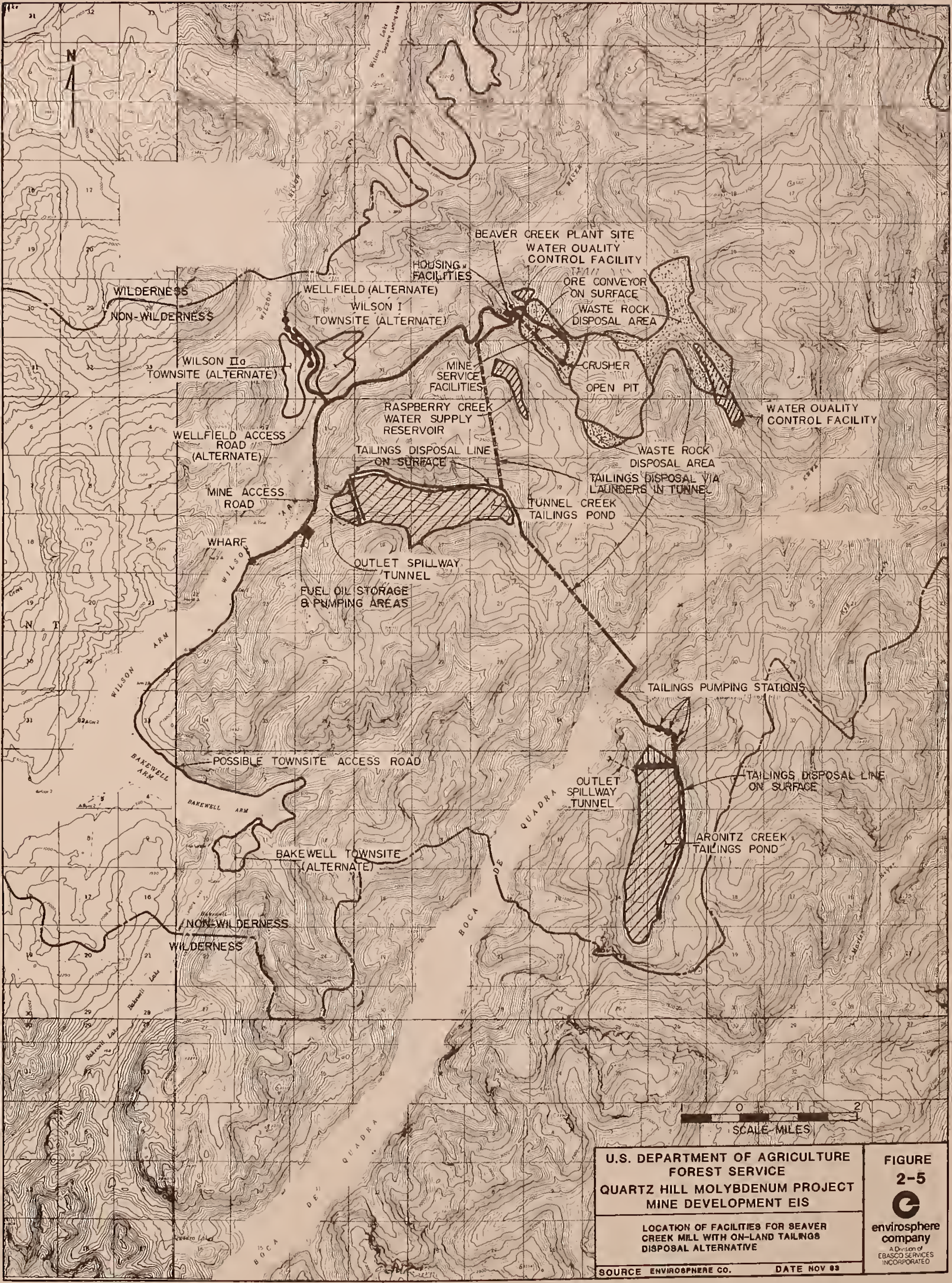
LOCATION OF FACILITIES FOR BEAVER CREEK MILL WITH BOCA DE QUADRA TAILINGS DISPOSAL ALTERNATIVE

SOURCE ENVIROSPHERE CO. DATE NOV 83

FIGURE 2-3

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 2-4
LOCATION OF FACILITIES FOR BEAVER CREEK MILL WITH WILSON ARM TAILINGS DISPOSAL ALTERNATIVE	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE ENVIROSPHERE CO. DATE NOV 83	



U.S. DEPARTMENT OF AGRICULTURE
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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOCATION OF FACILITIES FOR BEAVER CREEK MILL WITH ON-LAND TAILINGS DISPOSAL ALTERNATIVE

SOURCE ENVIROSPHERE CO. DATE NOV 83

FIGURE 2-5

envirosphere company
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U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOCATION OF FACILITIES FOR NORTH MEADOW MILL WITH BOCA DE QUADRA TAILINGS DISPOSAL ALTERNATIVE

FIGURE 2-6

envirosphere company
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SOURCE ENVIROSPHERE CO. DATE NOV 83

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOCATION OF FACILITIES FOR NORTH MEADOW MILL WITH ON-LAND TAILINGS DISPOSAL ALTERNATIVE

SOURCE ENVIROSPHERE CO. DATE NOV 83

FIGURE 2-7

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

operation of the potable water supply, the sewage treatment plant, and limited housing and services. The shutdown scenario would involve restarting production in 15 to 18 months with a workforce of 625. The workforce would be at full force within another 9 months when full production would be achieved.

No other waste rock disposal areas are considered viable alternatives due to the cost of hauling greater distances and over greater elevation gains and because no environmental advantages of other sites have been identified.

The runoff from the upper Hill Creek drainage basin could be diverted into North Creek to prevent this runoff from draining through the waste rock disposal area. The diversion would consist of a reinforced concrete rectangular channel. This channel would be protected from avalanches by berms, as feasible.

2.3.3 Crusher Alternatives

An alternative location for the crusher is at the northeast edge of the mine pit in the White Creek drainage. This site is practical only for the North Meadow mill alternative. The proposed facilities and operations at this site would be nearly identical to those of the proposed project.

2.3.4 Ore Transport Alternatives

Alternative ore transport routes are needed for the alternative mill sites at Beaver Creek and North Meadow. Crushed ore would be transported to the Beaver Creek site by a covered surface conveyor belt along Beaver Creek. For the North Meadow mill alternative the ore transport would be by conveyor belt along the north edge of the waste rock disposal area.

2.3.5 Processing Facility Alternatives

Beaver Creek Site

The Beaver Creek plant site would have essentially the same facilities as proposed at the Tunnel Creek site. The 210 ac site would be located at about 1,500 ft elevation on a ridge above Beaver Creek. Operations at this site in the winter could be impacted by the high snowfall at this elevation. There are two variants associated with the Beaver Creek plant site alternative involving location of the power plant facilities. The first variant involves location of the power plant in Tunnel Creek, while the second variant involves placement of the power plant facilities at the mill site at Beaver Creek.

North Meadow Site

The North Meadow site would also have essentially the same facilities as proposed at the Tunnel Creek site. The site is located at about 1,200-1,300 ft elevation just south of the divide between Hill Creek and North Creek in a relatively wide valley. Operations at this site

in the winter could be impacted by the high snowfall at this elevation. Power plant facilities would be located near the mill site. The waste rock disposal area would have to be redesigned somewhat to allow room for the processing facilities in North Meadow. This would likely result in the expansion of the area farther downstream on Hill and/or Beaver creeks or the raising of the disposal area.

2.3.6 Tailings Disposal Alternatives

Inner Basin Boca de Quadra Marine Tailings Disposal

Tailings would be transported from the mill site to the inner basin of Boca de Quadra for disposal. With a Tunnel Creek mill site a launder (open channel) in a 28,000-ft-long tunnel would be used to transport the tailings by gravity flow. For marine disposal in Boca de Quadra from the Beaver Creek or North Meadow mill sites, a combination of tunnels and surface pipelines could be used for tailings transport. Alternate alignments have been investigated that would result in a tunnel portal near the Keta River estuary or a portal at the tailings discharge point downfjord of the estuary.

During construction of a tunnel from the Tunnel Creek mill, approximately 120,000 cu yd of waste rock would be removed. Waste rock from the Tunnel Creek end would be used in facility construction, with excess placed in a disposal area. Waste rock at the Boca de Quadra end would be used for construction of the portal area. Access to the tunnel portal at the Tunnel Creek end would be by the Tunnel Creek access road. At the Boca de Quadra portal, a 1/4 mi access road and a small dock would be required. The Boca de Quadra tunnel portal facilities would occupy 25 ac.

A series of drop boxes would be installed at the Boca de Quadra portal to dissipate energy as the tailings drop to the discharge point. The tailings would be discharged into Boca de Quadra at a depth of approximately 150 ft. The quantities and types of tailings would be identical to those for the Wilson Arm disposal option. The seawater mixing box and discharge facilities would also be the same.

Middle Basin Boca de Quadra Tailings Disposal

If deemed necessary after several years of operation, during which tailings would be discharged to the inner basin as described above, the tailings line would be extended 15,000 ft to the middle basin. This pipeline would be a submerged, high-density polyethylene, double-walled line with a leakage sensing system between the walls. It would run along the surface of the tailings deposit.

Alternatively, tailings could be discharged directly to the middle basin throughout the life of the mine. Depending on the mill site, either a pipeline could be constructed from the tunnel portal to the middle basin, or the tailings tunnel could be realigned to go directly to the middle basin. The realigned tunnel would pass under Falsegate

Creek but would not be above ground in this area. The only disturbance in Falsegate Creek would be a very small area for a vertical shaft from the tunnel to allow for ventilation and to act as an escapeway. The tunnel portal at Boca de Quadra would be within the wilderness area, but would otherwise be similar to the portal that would be required if the location were at the inner basin.

On-Land Tailings Disposal at Tunnel Creek and Aronitz Creek

The on-land tailings disposal alternative involves the development of tailings dams and ponds in the stream valleys of Tunnel Creek and Aronitz Creek. This alternative would preclude the use of Tunnel Creek for the concentrator or the power plant. The proposed dams would be constructed of rockfill using quarried rock in a staged downstream construction method. Quarries for the rock would be located within the area to be inundated by tailings. The ultimate design heights and lengths of the dams are approximately 1,000 ft high, 1 mi long for the Tunnel Creek site, and approximately 780 ft high, 2/3 mi long for the Aronitz Creek site. The storage capacity for the Tunnel Creek site has been estimated at approximately 803 million tons, with 1,400 ac inundated by the tailings. The storage capacity of the Aronitz Creek site has been estimated at 730 million tons, with 1,300 ac inundated by tailings.

The on-land disposal option would require additional roads for access to the pipelines and tailings dams. This would involve construction of roads up Tunnel Creek and to the Aronitz Creek site. For the North Meadow mill site the access road and pipeline right-of-way to the Aronitz Creek site would be along Hill Creek and the Keta River to reach the dam site. Haul roads from the quarry areas to the dam sites would be located within the area to be inundated with tailings.

The tailings dams would be rockfill and would be constructed using the staged downstream construction method. Quarries for the rock would be located within the area to be inundated. During initial construction a diversion tunnel would carry natural streamflows. Upon completion of the starter dam the diversion tunnel would be plugged. Tailings pond discharge would be over a decant crest with a morning glory spillway provided to handle peak flows. The outlet would be operated to maintain low flows during droughts. During the staged construction, spillway capacity would be provided at all times to pass the routed Probable Maximum Flood.

The design of the tailings dams would minimize seepage. Runoff from natural areas above the tailings pond would be allowed to run into the tailings areas, since perimeter collection and diversion ditches are judged infeasible. The spillway decant system would be designed to provide storage between the maximum decant crest and the spillway crest for a sedimentation pool and the 10-year, 24-hour storm runoff.

Delivery of tailings from the Beaver Creek mill site would be by pipeline and a launder in a tunnel to the Tunnel Creek impoundment. Delivery of tailings to the Aronitz site would involve additional pipeline, another tunnel, and several pumping stations. For the North

Meadow mill site tailings would be delivered to the Aronitz site by a surface pipeline and to Tunnel Creek through a second surface pipeline. At the Aronitz Creek site a pumping facility would be required to move tailings up from the Keta valley to the site. A means of emergency disposal, consisting of an emergency holding basin near the lower Aronitz Creek, would be required in the event of a power failure or pump malfunction at the pumping station.

At the tailings impoundment water would be released to the natural drainage only after meeting best available technology (BAT), economically achievable, and best conventional pollutant control technology (BCT) NPDES permit effluent limitations for a "new" discharger, and after meeting Alaska receiving water quality criteria. At present dilution, settling and decanting are proposed to meet these limitations. Treatment would be added if needed. Release would be uncontrolled and would consist of natural inflows plus water recovered from the tailings slurry minus any water withdrawn to meet process water demands.

In the case of the Tunnel Creek impoundment, decant water would be pumped back to the mill for reuse as process water. Natural runoff water and water recovered from the tailings would completely satisfy the water requirement for the mill when the Tunnel Creek impoundment is in operation. Because of the much greater distance, elevation differences, and resultant cost, water would not be pumped back to the mill from the Aronitz Creek site and, hence, alternate water supplies would have to be developed.

Compliance with "New Source" NPDES permit limitations, which means zero discharge and complete recycling of water, was analyzed but judged infeasible. Due to the high volume of natural runoff, excess water is available beyond plant demands. Thus, complete recycle is not possible. In addition, recycle from Aronitz Creek would be extremely high in cost due to distance and elevation difference.

Reclamation of the tailings disposal areas would consist of stabilization and revegetation, if feasible, without the addition of topsoil, since there is no adequate source of topsoil. During the final years of operation, tailings would be placed to maximize reclamation potential. Neutralizer, fertilizer, and seed would be added to improve revegetation success. After storage of new tailings and water is no longer required, the spillway and decant outlet would be permanently plugged and the dam breached just above the tailings level to ensure that it no longer retains water. The face of the dam below the breach would be made into a spill channel with large rocks providing erosion protection. The owner/operator would be required to set up a permanent fund during project operation that would generate revenues for continued maintenance of the tailings dams.

2.3.7 Housing Alternatives

As an alternative to commuting from Ketchikan, a new community would be developed near the project site to provide both single status and family status housing and all related services. This housing could be developed in one of two ways:

1) Townsite option - development of a new, self-contained community that would be fully developed at the start of project operations.

2) Phase-In Option - a time-phased townsite development. Initially, most workers would commute from Ketchikan. The townsite would be developed gradually, with full town development completed in about 4 to 6 years after the start of production. The town would grow over the development period to a full service community of operations and service personnel and their families.

There are several alternative sites identified for townsite development. Any of these sites could be developed as part of either the townsite or phase-in options. Similar services and community facilities to those described below for the Bakewell townsite would be provided for any townsite with a few appropriate exceptions.

Bakewell

A permanent community at the Bakewell Arm site would occupy up to 200 ac east of Bakewell Creek. Housing facilities would include a mix of housing types to meet a variety of needs and preferences, such as single family homes, apartments, prefabricated and mobile homes, and houseboats.

At the Bakewell townsite the community would evolve from a 50-person floating construction camp to a 130-person land-based camp to a permanent townsite. This transition would allow flexibility in developing a mixture of housing types and should allow the best efficiency of building use.

Support facilities for the permanent community would include schools, a clinic, shopping center, recreation facilities, marina, and floatplane dock. The town would be compact, reducing the need for private cars. Internal roads and streets would be provided that connect the town to the wharf and ferry service to the Wilson wharf and Ketchikan. Eventually, a road connection to the plant site might be developed along the north shore of Bakewell Arm and the east shore of Wilson Arm or through a tunnel.

A water supply system, sewage collection and treatment system, and a community power plant would be provided at the townsite.

The acreage required for the townsite would be leased to U.S. Borax by the Forest Service for the duration of the Quartz Hill project. Any land transfers by the Forest Service to other ownerships would have to be consistent with the provisions of ANILCA.

Keta

If a project development were selected that would place a road in the Keta River drainage, the Keta townsite would be the alternative townsite as part of the "Keta alternative." The townsite would occupy about 120 ac adjacent to the Keta River estuary. The site is in close proximity to and may encroach on the floodplain of the Keta River, is in proximity to avalanche areas, and is in an area of high winds. The wharf location would be near the mouth of Aronitz Creek.

Wilson I

The Wilson I townsite is located on a ridge between the Wilson and Blossom rivers near their confluence. Rather extensive cutting and filling would be required to accommodate the townsite. Otherwise, an unusual number of multiple level apartment buildings would be required, thus lowering the flexibility of housing choices. The townsite access would be by a short road from the mine access road.

Wilson IIa

A Wilson IIa site is located on the west side of the Wilson River on the westernmost part of the valley above the floodplain. Some filling may be required to raise portions of the site above the floodplain. A town at this site would occupy the same area as the airport site. The access to the townsite would be by a short spur from the mine access road with a bridge over the Wilson River.

2.3.8 Other Support Facility Alternatives

Wharf Alternatives

Boca de Quadra Wharf:

If the mine access road were built in the Keta River drainage, the wharf would be built near the mouth of Aronitz Creek. The wharf facilities would be essentially the same as those for the wharf for the proposed project.

Upfjord Location for Wilson Arm Wharf:

This alternative involves the location of the wharf facilities upfjord (nearer the Wilson Arm estuary) of the present wharf rather than downfjord as envisioned in the proposed project. All permanent facilities would be the same as for the proposed project.

Access Road Alternative

The primary road alternative lies in the Keta River drainage. The lower end of the Keta road alternative begins at the wharf site on the east side of Boca de Quadra near its head. It runs along the southeast side of the fjord and the Keta River tidelands, crosses the Keta River, and follows the Keta River floodplain to a point near the confluence of Hill Creek and the Keta River. The road then ascends Hill Creek valley

along the southwest side past the confluence with White Creek to the North Meadow mill site. The total length of the road is slightly over 10 mi. The road would require bridges across Aronitz Creek and the Keta River. It would also cross about 1,500 ft of tide flats at the river mouth. It would be above the 100-year floodplain in most areas. In order to avoid avalanche areas along Hill Creek, approximately 4,000 ft of tunnel, 24 to 26 ft in diameter, would be required. If the Keta route is selected, the present bulk sampling access road along the Blossom River route would be reclaimed after completion of the new Keta road.

Water Supply Alternatives

Criteria used in the selection of potentially feasible water supply alternatives include (1) reliability, especially considering seasonal and annual low flow periods, (2) cost-effectiveness, and (3) major environmental impacts. The alternatives addressed below meet these criteria and are sources potentially suitable for a continuous mineral processing operation. Other water supply alternatives, which are not considered feasible, are addressed in Section 2.4.7.

A Raspberry Creek reservoir would disturb an area of approximately 180 ac and would impound waters from the high elevation Raspberry Creek drainage. No pumping would be required. The annual storable runoff from Raspberry Creek would be insufficient, and this source would have to be used in conjunction with another source. Problems with deep snow and ice would have to be overcome.

An upper Hill Creek reservoir would disturb about 100 ac. A pipeline from upper Hill Creek would traverse dangerous landslide and avalanche zones and would affect mining operations. The upper Hill Creek reservoir would also have to be used in conjunction with another source.

Two dams would be required for a North Meadow reservoir on the saddle between Hill Creek and North Creek. The annual storable runoff may not be sufficient to allow this to be used as a sole source. Winter problems with the high elevation would have to be overcome.

An Upper Lakes reservoir would be located on the high ground of a small drainage on the west side of Wilson Arm opposite the proposed marine terminal. A wharf would be provided for access with a steep road to the reservoir. A pipeline would cross Wilson Arm buried in a trench in the bottom sediments.

A well field on the Wilson River at a site upstream of the confluence with the Blossom River could be used as a supplemental water supply in conjunction with a Tunnel Creek reservoir. The well field could provide supplemental water up to the maximum plant demand of approximately 16,000 gpm.

The proposed water supply system could meet various instream flow requirements in Tunnel Creek. U.S. Borax has proposed a 5 cfs release at the dam. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have suggested instream flows at the downstream velocity barrier that vary by season, as follows: 90 cfs from July 1 to November 30; 15 cfs from December 1 to March 31; and 30 cfs from April 1 to June 30. Meeting the higher instream flow requirement would require more pumping from the supplemental Blossom Creek water source.

If Tunnel Creek is used as a sole water supply source, a larger reservoir would be required than for alternatives having a supplemental source. The dam would be 175 ft high and would require 3,350,000 cu yd of fill material. The full reservoir would occupy 136 ac and would have a capacity of 8,940 ac ft. These dimensions assume a 5 cfs minimum flow requirement. If no minimum flow is required, the dam could be about 5 ft lower and the reservoir 7 ac smaller. If a higher minimum instream flow is required, then the dam and reservoir would necessarily be larger.

2.4 OTHER ALTERNATIVES ELIMINATED FROM DETAILED STUDY

Several alternative components have been considered, but have been eliminated from detailed study because of major engineering problems in implementing the alternative, excess economic costs, and/or severe environmental problems that cannot be adequately mitigated. These alternatives are listed below. Appendix A provides a more complete explanation of the engineering, economic, and/or environmental rationale for their elimination.

2.4.1 Mine Site Facility Alternatives

The only alternatives eliminated from detailed study are the following:

- Underground mining. Underground mining would not be feasible for this ore body due to its proximity to the surface and the significantly higher costs of underground mining.

- Waste rock disposal in more distant valleys such as Tunnel Creek, Taylor Creek, or Smith Creek. The economics of hauling waste rock over large distances preclude use of these valleys. In addition, no environmental advantage to their use has been identified.

- Sidehill diversion channels upslope of the waste rock disposal areas. These diversions would intercept overland runoff and small streams before they enter the waste rock disposal areas. Diversion would create serious engineering and maintenance problems such as clogging of the channels with the large amounts of natural debris in the drainage area, blocking or destruction of the channels by avalanches, and potential for increasing landslides below the channels.

2.4.2 Crusher Alternatives

The only alternative eliminated from detailed study is the following:

- o Crusher at the mill site instead of the mine. Truck transport of ore to the crusher is the only feasible transportation mode. This would result in higher fuel usage and the need for a more extensive haul road network than would an on-mine-site crusher. Thus, there are environmental, engineering, and economic disadvantages.

2.4.3 Ore Transport Alternatives

The alternatives eliminated from detailed study are the following:

- o Rail. The cost of this system would be higher than a conveyor. It offers no environmental advantages, and the power generating capacity of the belt conveyor would be lost.

- o Tramway. The tramway route would result in additional environmental impacts (additional disturbed acreages and reduced aesthetics) and no engineering or economic advantages.

- o Truck. The grade and distance to any of the potential mill sites would make truck transportation very expensive. The road system would have to be upgraded, resulting in additional disturbed area. The potential for worker injuries or fatalities would be greater than for the belt conveyor.

- o Slurry. Engineering problems associated with crushing and grinding the ore at the mine site and a water supply for slurrying make this infeasible.

- o Barge transport to off-site mill. Transportation costs of raw ore would be 600 to 700 times higher than the cost of transporting molybdenum concentrate.

2.4.4 Processing Facility Alternatives

No other processing facility locations were considered that were eliminated from detailed consideration.

2.4.5 Tailings Disposal Alternatives

The tailings disposal alternatives eliminated from detailed study are the following:

- o Ocean tailings disposal. Preliminary estimates indicate that this is prohibitively expensive, roughly 100 times the cost of submarine disposal to the fjord.

- Diversion channels above on-land tailings disposal areas. Very large diversion channels excavated in rock on steep slopes would be required to handle the high runoff characteristic of this region. The diversion channel could be blocked by avalanches, landslides, and normal debris that would be likely in these areas. Due to the possibility of blockage during a critical runoff event, the dam and related facilities would have to be designed assuming an inoperational ditch. Thus, no significant benefits would be gained by installing a diversion channel.

- On-land tailings disposal at sites not including Tunnel and Aronitz creeks. Small quantities of tailings could be placed in several small valleys, but only Tunnel and Aronitz creeks appear to offer storage on the order of one half of the projected need. In addition, valleys discharging into one of the major rivers appear less suitable environmentally because runoff would severely affect aquatic life in the streams.

- On-land tailings disposal with ultimate backfill to pit. Because of the nature of the open pit mining process, on-land tailings dams would still be required until the end of mining. This method results in extremely high costs, engineering difficulties, and no environmental advantages (the on-land tailings areas would still be impacted throughout the 55 years of the mine life).

2.4.6 Housing Alternatives

Townsite locations eliminated from detailed study are Wilson III and IV along the Wilson River, Tunnel Creek, Fuel Cache above the mine access road, East Knoll above the mine access road, and Aronitz in the Aronitz valley. These sites were eliminated due to environmental reasons that made the sites undesirable for living and/or resulted in significant impacts.

2.4.7 Other Support Facilities Alternatives

No additional alternatives for the wharf or access roads have been identified. The following electric power alternatives have been identified but were eliminated from detailed study:

- Alternative fuels including natural gas and propane. Neither of these fuels appear to be feasible from an engineering or economic standpoint at this time.

- Alternative technologies including on-site nuclear, coal, and hydropower plants. These were eliminated for engineering and economic reasons.

- Diesel-powered generators. No engineering, economic, or environmental advantages of these units for this project have been identified.

- Transmission line intertie. Preliminary planning of this alternative is not sufficient to permit a full evaluation in this EIS. If it is considered at a later date, a supplemental EIS will be prepared.

The following are water supply alternatives eliminated from detailed study:

- Mine drainage. The quantity of water available from this source would increase gradually during the life of the mine, reaching only 50 percent of total demand at the end of the mine's life. Thus, in the early stages of mining, alternate water supply sources would still have to be developed for virtually the entire water supply. Because much of the pit drainage would come from snowmelt and storm runoff, conveyance pipelines to a storage site in Tunnel Creek would have to be oversized to convey the peak flows. Therefore, this alternative was eliminated because of economic costs and a lack of environmental advantages.

- Water quality control dams. The use of these dams for dual purposes as water quality control/water supply facilities would involve redesign of the dams and would not eliminate the need for other water supply sources. Thus, other water supplies would probably still have to be developed. In addition, the seasonal timing of water availability from these basins would be similar to that of other surface water basins. Due to the costs and impacts of raising the water quality control dams, costs of pumping to the plant site, costs and impacts of additional pipelines required, and therefore, an overall lack of environmental advantages, this alternative was eliminated from detailed consideration.

- Other small sources. Since the seasonal runoff is highly variable in these streams, other more reliable sources would still be required to meet plant water demands during low flow periods. Development of these basins would require additional corridors for access roads, pipelines, pumping stations, and power lines. This would result in significantly higher costs and greater environmental impacts than the proposed water supply system.

- Desalinization. This source would be extremely costly and energy intensive. Because of the added energy requirements, additional generation capacity would be required with attendant increases in fuel consumption, water use, and emissions.

- Seawater. Tests indicate that the high concentrations of dissolved salts in raw seawater interfere in the efficient recovery of mineral from the ore.

- o Dewatering of tailings. This alternative was eliminated due to unresolved engineering factors regarding dewatering of slimes (very fine particles) in the tailings. There are no similar operations of comparable size. Thus, for engineering and economic reasons, this alternative was eliminated from detailed consideration.

- o Blossom River well field. Geologic and geophysical test work has indicated that the Blossom River aquifer cannot provide a primary source of water needed for plant demands.

- o Wilson River tributary reservoir. Location of a reservoir on a major but unnamed tributary of the Wilson River located a short distance upstream of a possible well field was eliminated from detailed consideration. This alternative was eliminated due to economic reasons and major environmental disadvantages. The alternate would need bridges crossing the Wilson River and possibly the Blossom River, thus spreading project facilities to a new area west of the Wilson River and to another spawning stream.

Development of an airport near the Quartz Hill project has been eliminated from detailed consideration due to uncertainty of the need for such a facility, hazards at possible sites, and availability of floatplane landing sites.

2.5 COMPARISON OF ALTERNATIVES

This section summarizes some of the more important environmental impacts of the proposed project and the alternatives. It is presented to aid the reader in comparing impacts of the numerous alternative components (i.e., facilities and facility locations). By limiting the impacts discussed here, a more concise comparison can be presented. Costs of the alternatives are provided in Section 2.6 and may be used in conjunction with this comparison of environmental impacts. Chapter 4.0 of this EIS, which presents a very detailed discussion of the environmental effects of all alternatives, should be read for a complete understanding of project impacts. The no action alternative described in Chapter 4.0 is not summarized here.

For each component, the major impacts of the proposed project are described first, followed by a description of impacts of the alternatives. Important mitigation measures that are not already included in the proposed project or alternatives are summarized with the descriptions. Except for the proposed project, the various components are not assigned to concepts in this section as they are elsewhere in this EIS. Also, for ease of comparing impacts, some components are discussed together in this section (e.g., processing facility and on-site power generation), whereas they are discussed separately elsewhere in this EIS.

2.5.1 Mine Facilities

The mine facilities include the open pit at Quartz Hill and Bear Meadow, the associated mine service facilities, and the waste rock disposal areas in Beaver, White, and Hill creek drainages. The mine pit would be in the ore body, and the waste rock disposal areas would be at the only feasible sites near the pit that are capable of containing the large volume of waste rock. No alternatives are considered for these components.

The proposed mining project would use a nonrenewable geologic resource by removing the ore body. Excavation of the pit and disposal of waste rock would permanently change local topography. During the post-mining period, glacial till would be spread over the waste rock to reestablish a topsoil cover and promote revegetation.

During the mining phase, project activities would affect the surface water flows of Beaver, White, Hill, and Tunnel creeks. The hydrologic regime of virtually all of White Creek and substantial portions of Hill and Beaver creeks would be essentially eliminated by development of the waste rock disposal areas and the pit. Annual flows and low flows in Beaver Creek downstream of the water quality control pond would be affected because of changes in upstream runoff characteristics, particularly from the waste rock areas, and because of changes in drainage area as the pit is developed. Impacts on Hill Creek annual flows would be small. In the first 6 years of mining when the pit area, part of which is now in the Hill Creek drainage, would drain to Beaver Creek, low flows would become lower on Hill Creek. In subsequent years when the pit drainage would be pumped to Hill Creek, moderate increases in flows above natural levels would be expected in Hill Creek.

In the post-mining period, long-term impacts in Beaver Creek would continue to be moderate due to the continued effects of changed runoff characteristics and decreased drainage area. During approximately the first 14 years after the completion of mining, the pit would be filling with water and would not discharge. After the pit filled with water, it would discharge to Hill Creek.

Water quality impacts could result from discharges from project-related facilities during both construction and operation. However, these impacts would be minimized by a waste rock handling plan to reduce the possibility of acidic waste rock drainage, by secondary treatment for sanitary sewage, and by treatment of oily wastes and recycling of waters where feasible. Furthermore, discharges from all facilities would be routed to water quality control facilities (ponds) designed, operated, and modified if necessary to meet ADEC Receiving Water Quality Standards at the boundaries of approved mixing zones. During operations, Beaver Creek and Hill Creek would be degraded somewhat by increased suspended and dissolved solids. Beaver Creek would be affected by access road erosion, runoff from facility sites and waste rock areas, pit dewatering flows during the early years of mining, and

wastewater discharges. Hill Creek water quality would be impacted by runoff from waste rock disposal areas and mine haulage roads and pit dewatering flows in the later years of mining.

Despite avalanche control procedures, the likelihood of an uncontrolled avalanche in the mine pit or on some sections of access roads is still judged to be relatively high. Since such an event could involve damage to property, personal injury, or loss of life, potential impacts are considered very significant.

Impacts on the freshwater ecology of the Blossom River basin would be moderated by a water quality control facility on Beaver Creek. During both normal flow and flood conditions, impacts on fish populations from project effluents would be insignificant. Impacts on fish populations as a result of flow reductions and water withdrawals are expected to be insignificant in Beaver Creek and nonexistent in the Blossom River.

Project operations would eliminate all resident fish populations and habitat in White Creek and Hill Creek above the final water quality control dam. However, the dam would be located upstream of the natural anadromous fish barrier in Hill Creek. The only salmonid species in upper Hill Creek, Dolly Varden char, is not currently exploited by a sport fishery. Water quality control facilities would control effluents from the project, resulting in no impacts on fisheries during normal flows and insignificant impacts during flows exceeding the 10-year, 24-hour runoff. The operation of the water quality control ponds during low flows would allow outflow to be about the same as inflow. Thus, no flow-related impacts are expected in lower Hill Creek or the Keta River.

The greatest impact on vegetation from project construction involves direct disturbance or removal of vegetation from about 2,900 ac. This is from all project components. Despite reclamation at the end of the project, the succeeding vegetation would differ from what previously existed and would support less wildlife. These changes would only affect a fraction of a percent of each vegetation type in the region.

Mountain goat populations could be affected by project noise and activity, which could cause them to move away from the project area and therefore stress the carrying capacity of adjacent areas. Mountain goat populations could also be impacted by increased hunting pressure. The cumulative effect of all potential project-induced impacts on mountain goats could be very significant.

Mitigation for unpreventable losses of wildlife, especially mountain goats, will involve transplant projects to increase populations in underutilized habitat. The transplanting of mountain goats could potentially compensate for the project-related loss of mountain goats, and also serve as out-of-kind mitigation for other wildlife losses. The total cost of such a mountain goat transplant program might range from about $25,000 to about $40,000.

Visual impacts of the project would be caused by the introduction of industrial facilities into a presently natural area. The mine pit and related facilities are not visible from the surface of Wilson Arm, but persons viewing from aircraft, primarily above Wilson Arm, would notice the visual contrasts.

2.5.2 Processing, On-Site Power Generation, and Road Facilities

The project must include an ore processing mill and a supply source for process water. Because the proposed and alternate on-site power generators are associated with the mill, their impacts are also included here. Alternative mill locations are on Beaver Creek and in North Meadow. Roads required for the alternative mill locations are also addressed here, as are all road alternatives to the mine facilities.

Proposed Project

The proposed project includes an ore processing facility at Tunnel Creek. Associated with this location is a process water supply, which would include a reservoir upstream of the facility on Tunnel Creek and a supplemental water supply from the Blossom River.

The power plant would be adjacent to the mill. The existing road to the mine area would be widened and a new road built to the Tunnel Creek mill.

The Quartz Hill project is considered to be two distinct and separate air quality sources. The Tunnel Creek power plant site is subject to the requirements of the Prevention of Significant Deterioration (PSD) program. The SO_2, NO_x, and carbon monoxide emissions are limited such that air quality impacts would be much less than the allowable PSD increments or Alaska State Ambient Air Quality Standards (ASAAQS). The mine site includes an ore crusher, which is subject to New Source Performance Standards; however, emissions at the site will not be high enough to key PSD. The ambient concentrations will comply with ASAAQS.

Impacts on surface water flows in the Blossom and Keta rivers would be insignificant. Withdrawal of process water for the mill and power plant from Tunnel Creek would reduce flow patterns in that stream, potentially affecting salmon habitat. Mitigation, consisting of meeting instream flow requirements has been committed to, although the level of minimum streamflow has not been established at this time.

Water withdrawal from the Blossom River would serve as a supplemental water supply. Pumping would draw water indirectly from the river. This would be achieved by installation of a filter bed with perforated piping and a series of intake pipes leading to a pumping station on shore. The vertical turbine pumps would be located above the highest flood levels. The pumps would withdraw water from the river during periods of low flow in Tunnel Creek and, through a 30-in.-diameter pipeline, deliver the water to a booster pumping station for conveyance to the plant site. When high tides create excessive salinity at the intake that could affect the metallurgical process, pumping would stop,

and water would be withdrawn from the Tunnel Creek reservoir storage or the plant site day tank. This would eliminate the need for the weir that was previously described in the Revised DEIS. Impacts from withdrawal would be insignificant because flows for the upstream and downstream passage of fish would be maintained and areas downstream of the site do not support significant spawning habitat. Also, the filter bed system used to collect water would avoid potential fish entrainment and impingement problems.

Potential water quality impacts during construction would consist primarily of increased sediment loads in Tunnel Creek, Beaver Creek, and other smaller tributaries of the Blossom River. However, the potential impacts would be minimized by sediment control measures and suitable construction practices. Impacts on the Blossom River, the Wilson River (downstream of the confluence with the Blossom), Beaver Creek, and the small tributaries are expected to be insignificant, except that occasional landslides along the access road during widening could result in substantial short-term increases in sediment load.

During the operations period, there would be some increase in sediment load in the Blossom River and Tunnel Creek due to erosion of the access roads. From a water quality standpoint, impacts of any spills of fuels or chemicals would be insignificant due to the short duration of the impacts and the use of cleanup techniques to minimize longer term impacts. The biological impacts of spills are discussed separately later in this section.

Freshwater biology impact studies concentrated on the effects to the four major species of salmon (pink, chum, coho, and chinook), Dolly Varden char, and their habitats. Assuming minimum streamflows and flushing flows are established and maintained for Tunnel Creek, impacts on fish resources from water withdrawals and from construction and operation of the Tunnel Creek access road would be insignificant. No additional significant impacts are expected from the power plant and mill during normal operations. Tunnel Creek would be vulnerable to spills of milling reagents carried by truck and diesel fuel carried by pipeline to the mill and power plant. Though the probability of spills is low, the potential for damage from a major spill would be substantial. Spilled chemicals could cause a severe increase in mortality to all forms of aquatic life within the affected area.

Widening of the mine access road, construction of the road to the Blossom River supplemental water supply source, and use of these roads during the mining phase could generate sediments that would have a moderately significant impact on salmon in the Blossom River. Although the probability is low for a major spill of petroleum products or explosives occurring in or reaching the streams, there are potential impacts on the Blossom River and its tributaries from spills.

Several measures have been identified to mitigate impacts on freshwater biology. Spawning gravels clogged with sediment will be cleaned. Costs of gravel cleaning are estimated to be \$0.22-\$1.25/yd^2. Incubation boxes are a method of supplementing salmon production in streams, which enable the use of indigenous stocks as an egg source.

If needed, egg boxes will be placed along the Blossom River with water supplied from the supplemental water supply. Costs are approximately $1,000 per box. Spawning channels on the lower Wilson, Blossom, or Keta rivers would increase spawning habitat and optimize the physical conditions. In general, costs would average $35-$40/yd^2. Spawning channels require periodic maintenance for cleaning of spawning gravels and servicing of water control structures. If needed, fishways and barrier modifications will provide fish access to spawning and rearing habitat and result in enhancement of indigenous salmon stocks. Passage projects can range from simple blasting of falls and barriers to the construction of massive fish ladders.

Beaver Creek Mill

With a Beaver Creek mill, the power plant could be located either at the mill site or in Tunnel Creek. With a Tunnel Creek power plant, the impacts on the Tunnel Creek valley would be essentially the same as for the proposed project, and impacts discussed below for Beaver Creek would also occur. A Tunnel Creek power plant would require the reservoir at Tunnel Creek. With the power plant at Beaver Creek, impacts would be as discussed below, and impacts in Tunnel Creek would be insignificant.

With the mill in Beaver Creek, the water supply could be from the Raspberry Creek reservoir, with additional supplies from a Wilson River well field or an intake facility on the Blossom River. Flows in Raspberry Creek would be substantially reduced by the water withdrawals, since average monthly flows at the reservoir for all months of the year are less than process demands. Impacts on the fish resources of Wilson River from operating the well field are expected to be small during all but the lowest flow periods of the Wilson River. If very low flows occur during the incubation period, the impacts could be significant on a short, but very productive, reach of salmon habitat. Compliance with instream flow requirements would minimize these impacts. The frequency of withdrawals from the Wilson River well field would be greater with a Raspberry Creek reservoir than with the Tunnel Creek reservoir. As discussed under the proposed project, impacts of a supplemental water supply from the Blossom River would be minimal.

The likelihood of spills of fuels and chemicals would increase due to the longer haul distances to a Beaver Creek site and the more adverse winter weather conditions at the higher elevation compared to a Tunnel Creek site. Other impacts to project area streams would be essentially the same as for the proposed project.

Impacts on the freshwater ecology of Tunnel Creek would be eliminated if both the mill and the power plant are at Beaver Creek. Diversions of water from Raspberry Creek could impact fisheries in the lower reaches of this stream, where there is some habitat utilized by salmon, trout, and char. An instream flow study would be needed to determine flows necessary for maintaining fish habitat. Wildlife impacts would be consolidated into a smaller area and would be eliminated from Tunnel Creek.

North Meadow Mill

This alternative could obtain process water from a reservoir on upper Hill Creek and supplemental water from the Hill Creek water quality control pond. The North Meadow mill concept includes a new mine access road from the Keta River, the wharf in Boca de Quadra, and removal of components from Wilson Arm and the Wilson and Blossom river drainages.

Surface water flows in Hill Creek would be reduced during average flow periods due to withdrawals for process water. If instream flow requirements are not maintained, significant impacts on Dolly Varden char in upper Hill Creek and anadromous salmonids in the lower reaches of Hill Creek could result. Instream flow studies would be performed to aid in assessing appropriate minimum flows. Impacts to Tunnel Creek and the Wilson and Blossom rivers would be eliminated. There would be no groundwater impacts on the Wilson River since the well field would not be included.

The access road for this concept would extend from Boca de Quadra along the Keta River and up Hill Creek. The Hill Creek section traverses very steep and difficult terrain. Landslides would be more likely during construction and operation than would result from upgrading the existing bulk sample road under the other alternatives. If the Keta road is built, the existing road would be fully reclaimed.

Due to the greater road length and the more adverse winter weather conditions, accidental spills of chemicals and fuels are more likely than with the proposed project. If a spill occurs, impacts would be very significant for a short period. These impacts would occur in Hill Creek and/or the Keta River. Sediment-related impacts would increase in Hill Creek and the Keta River due to runoff and landslides from the Keta River access road.

Placement of mill facilities at the North Meadow site would result in increased exposure of workers to avalanche hazards. Several destructive avalanche zones occur in close proximity to this alternative mill site location, and travel along the Keta River access route would also expose workers to increased avalanche hazards.

The impacts on wildlife would be similar to those of the proposed project. There would be no project components constructed in the Wilson Arm drainage except for waste rock disposal in Beaver Creek; rather, construction and operational impacts would affect the Keta drainage. Disturbance of the Keta estuary area by the access road would cause a substantial reduction in wildlife usage of this important habitat, but impacts to the wildlife using the Wilson estuary would be eliminated.

Other Water Supply Alternatives

In addition to the water supply alternatives described above for alternative mill sites, several other water supply alternatives have been identified. These include a North Meadow reservoir, an Upper Lakes reservoir, and Tunnel Creek as a sole source.

North Meadow Reservoir:

North Meadow reservoir impacts on Hill Creek would be similar to those described above for the upper Hill Creek reservoir alternative. There would also be similar impacts on North Creek.

Upper Lakes Reservoir:

An Upper Lakes reservoir would extend project impacts to the west side of Wilson Arm, increasing the area of project disturbance including the sensitive Wilson River estuary. Impacts of this water supply alternative on fisheries would be nil since no fish are known to inhabit the existing lakes, and the outlet stream is too steep for fish habitat.

Tunnel Creek Sole Source:

If instream flow requirements are met, the impact of the larger dam and reservoir on freshwater and terrestrial ecology would be minor. Partial streamflow would be maintained based on inflow to the lower part of Tunnel Creek. The impacts are similar to those discussed for the proposed project.

2.5.3 Tailings Disposal

The proposed project includes submarine tailings disposal in Wilson Arm/Smeaton Bay. Tailings discharge would be near the Wilson Arm wharf. Alternative tailings disposal systems include submarine disposal to the inner basin of Boca de Quadra via a tunnel from the Tunnel Creek mill site, submarine disposal in the middle basin of Boca de Quadra, either throughout the life of the mine or starting after several years of disposal in the inner basin, and on-land disposal in Tunnel and Aronitz creek valleys. The impacts of each of these alternatives are summarized below for comparison. Alternative tailings tunnel alignments from the Tunnel Creek and Beaver Creek mills to outfalls in Boca de Quadra and their impacts are discussed in Section 2.5.6.

In order to compare the three major submarine tailings disposal alternatives, their major impacts are given in Table 2-2 as if each were to be used with the Tunnel Creek mill.

<u>Proposed Project</u>

Tailings deposition in Wilson Arm would fill about 78 percent of the below-sill volume of Smeaton Bay in the 55-year life of the mine operations. During the first 5 years of operation, tailings deposition would occur primarily in Wilson Arm. The tailings surface would reach the top of the intermediate sill of Smeaton Bay in about 20 years. The resulting depth of the bay at year 55 would range from 250 ft (75 m) at the outfall to 580 ft (175 m) at the outermost sill. As the Smeaton Bay basin fills, deep water renewal would become less effective as a circulatory driving force. The flushing rate of the fjord would decrease as the circulation patterns weaken. Therefore, the hydrography and circulation of the nonsurface waters would change

TABLE 2-2

COMPARISON OF IMPACTS OF TAILINGS DISPOSAL
IN THE THREE BASIN ALTERNATIVES WITH A TUNNEL CREEK MILL

	Disposal Basin Alternative		
Impact	Wilson Arm/ Smeaton Bay	Inner Basin Boca de Quadra	Direct to Boca de Quadra Middle Basin
Would change circulation of the discharge basin	Yes	Yes	No
Tailings would impact salmon	No	No	No
Reduction in below-sill fjord volume	78%	100%	15%
Resulting fjord depths	75 to 100 m over about 30% of basin	80 to 100 m over about 100% of basin	More than 140 m over about 98% of basin
Change in resulting ecological community structure	To community of shallower depth	To community of shallower depth	No
Annualized loss of dungeness crab	960 kg	1,630 kg	660 kg
Annualized loss of pot shrimp	480 kg	740 kg	250 kg
Annualized loss of demersal fish	4,570 kg	7,070 kg	2,790 kg
Suspended tailings may reach near-surface waters	Possibly at sills	Possibly at sills	Possibly at sills

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significantly. Impacts to the upper-water zone of Wilson Arm/Smeaton Bay from tailings-related turbidity are expected to be insignificant. As each basin is filling, turbidity will affect the deep water above the tailings deposition zone. Small quantities of tailings fines will be transported over the Smeaton Bay sill and into Behm Canal. The concentrations would probably be below detection levels, and insignificant impacts would result.

The tailings slurry would also contain dissolved trace metals and milling reagents. Trace metals would exceed the EPA marine water quality criteria for total recoverable concentrations near the outfall and in a turbidity plume up to 40 ft thick flowing along the fjord bottom. A mixing zone and a zone of deposition, if approved, could make the estimated concentrations permissible. Beyond the near-field dilution area, trace metals may also continue to be released from the tailings solids. For the metals that exhibit either no release or rapid release, dissolved concentrations should not exceed those in the near-field discharge plume. Molybdenum and manganese may continue to be released from the tailings solids following discharge. However, released dissolved constituents will be subject to natural removal mechanisms such as adsorption and precipitation. Experience at similar mining operations suggests that tailings leaching would not result in degradation of water quality. However, differences in fjords and amounts of tailings to be discharged make it impossible to estimate potential increases in dissolved ambient concentrations with the available data.

Effects on marine ecology from tailings disposal would result, in order of importance, from burial of marine organisms, suspended sediments, and toxicants present in tailings. Rapid sediment accumulation on the bottom would affect several important species, including dungeness crab, tanner crab, pot shrimp, trawl shrimp, walleye pollock, rockfish, and flatfish. Suspended solids would affect marine organisms primarily in the turbidity plume where tailings are actively being deposited. Toxicity and bioaccumulation are not expected to affect organisms that would not already be affected by burial or suspended sediments, but further tests for some milling reagents may be required before tailings disposal begins. Suspended tailings are not expected to reach the photic zone. Therefore, effects on seaward migrating anadromous fish and on plankton in the fjord would be insignificant. Direct impacts on herring are not predicted, but possible indirect impact through habitat loss may occur. While actual reduction of overwintering herring populations cannot be predicted from existing information, a reduction of potential overwintering habitat can be estimated. Assuming herring use fjord waters to a depth of 140 m, 2.5 percent of the regional herring habitat, i.e., the total combined volume of Boca de Quadra and Wilson Arm/Smeaton Bay (to the outer sills) would be unavailable because it is occupied by tailings. If one assumes that herring might avoid suspended sediments at concentrations greater than 20 mg/l, then 7.8 percent of the total habitat would be avoided because of suspended sediment concentrations.

Tailings discharge into Wilson Arm/Smeaton Bay provides the overall advantage of limiting all project impacts to one fjord basin. All impacts to Boca de Quadra and wilderness areas to the south would be eliminated. After tailings deposition is completed, the Smeaton basin would be much shallower. Some deep water species populations would be reduced, and other species (e.g., dungeness crab) would be enhanced after deposition ceases.

Submarine Disposal in Inner Basin of Boca de Quadra

During the mining phase, coarser tailings material would be deposited in the deeper parts of the inner basin of Boca de Quadra, while the fines would be deposited over the entire basin below the depth of the tailings outfall, probably including some of the submarine slope of the Keta River delta. After approximately 14 years of operation, deposition modeling indicates that the below-sill part of the inner basin would be mostly filled and that the bulk of the tailings would move downfjord over the inner basin sill. At the completion of the project, the region of deposition would extend approximately 16 miles into the middle basin. Impacts to the upper-water zone of Boca de Quadra from tailings-related turbidity are expected to be insignificant. Turbidity impacts to the below-sill and near-sill-depth waters of the inner basin could be substantial during filling because of the relatively small volume of the inner basin.

Trace metal constituents of the tailings slurry are expected to result in effects in the inner basin similar to those for the proposed project. Based on the most recent information, dissolved oxygen depletion is not expected to be a problem.

Effects on marine ecology would be similar to those of disposal in the Smeaton basin. The same general groups of species would be affected, but the numbers would be slightly different. Reduction of herring habitat (using the same assumptions as for the proposed project) would include tailings occupying 2.6 percent of the total combined fjord volume. Suspended sediment at concentrations above 20 mg/l would occupy 17.6 percent of the total combined volume.

Submarine Disposal Initially in Inner Basin and Later in Middle Basin of Boca de Quadra

The impacts of this alternative would be essentially the same as for the disposal to inner basin alternative, assuming tailings will flow over the sill and into the middle basin after several years of operations as predicted. If the tailings do not flow into the middle basin as predicted, this alternative would extend the tailings pipeline on the tailings surface for relocation of the outfall to the middle basin after the inner basin is filled. The relocated outfall would provide increased dilution for the remainder of the project similar to those described for disposal to the middle basin throughout the life of the project. Benthic organisms could completely recolonize the inner basin after the outfall is moved to the middle basin.

Submarine Disposal Only in the Middle Basin of Boca de Quadra

Impacts to the middle basin would be similar to those described for this basin in the disposal to inner basin alternative. Impacts to the inner basin would be mostly eliminated. Some of the mechanisms that could move tailings into the near surface waters are not as strong or as likely to occur in the middle basin as in the inner basin. If the middle basin outfall were reached via a submarine pipeline from an inner basin tunnel portal, a pipeline break during operation could release tailings into the surface waters of the fjord. A tunnel constructed directly to the middle basin would eliminate both the need for a pipeline along the western inner-basin boundary and the possibility of pipeline ruptures and accidental tailings discharges into the inner basin. However, the tunnel portal would be in the wilderness area.

Impacts on chemical oceanography of the middle basin would be similar to those of the disposal to inner basin alternative. With this alternative, the impacts on the physical oceanography of the inner basin would be insignificant, limited to only the sedimentation of tailings fines that may move upfjord over the inner basin sill. Impacts on water quality resulting from discharges in the middle basin would be less than those for discharge to the inner basin. The increased volume of water available for dilution in the middle basin would result in increased dilution and in lower dissolved trace element concentrations both in the near field and at a distance from the outfall.

Marine biology impacts on the middle basin itself would be generally similar to those described for this basin in the disposal to inner basin alternative. Reduction of herring habitat (using the same assumptions as for the proposed project) would include tailings occupying 0.4 percent of the total combined fjord volume. However, suspended sediment at concentrations above 20 mg/l as modeled by Kowalik, would occupy 21.9 percent of the total combined volume. The inner basin would be affected much less with this alternative. If a pipeline break released tailings into the inner basin surface waters, a number of organisms could receive short-term impacts of varying severity. Sedimentation in the inner basin from tailings fines moving upfjord over the inner basin sill should be low enough not to cause significant losses from burial.

On-Land Disposal in Tunnel and Aronitz Creeks

Nearly the entire lengths of Tunnel and Aronitz creeks would be buried, and the hydrologic regimes and fish habitat of these streams would be essentially destroyed. Water releases downstream of the impoundments would only be to a short segment of Tunnel Creek and, for the Aronitz Creek site, directly to Boca de Quadra. The elimination of marine tailings disposal would result in elimination of the associated impacts to the marine environment.

Water quality impacts on the fjords during normal operations would be insignificant. During operations, water would be released only after meeting EPA and ADEC limitations and standards.

A large potential impact from this alternative would be from a tailings dam failure, although catastrophic failure is very unlikely. A total failure when the dam was nearly full would kill all organisms in the affected areas. Affected areas for the Aronitz Creek dam would include the estuary and inner basin of Boca de Quadra. Some mortality might also occur in the middle basin, but probably not the outer basin. A Tunnel Creek dam failure would affect the estuary and Wilson Arm, with some mortality also expected in Bakewell Arm and Smeaton Bay, but not beyond. Residual effects could extend over several years, with increased turbidity retarding primary production.

For on-land disposal, the mill would be at Beaver Creek or North Meadow, and long tailings slurry pipelines would be on the surface, with or without alternative tunnels. A major break in a tailings pipeline is unlikely, but tailings entering either the Blossom or Keta river would significantly degrade water quality and fish habitat. Impacts of a tailings spill in either the Blossom or Keta river estuary would also have significant impacts, particularly if it occurred in a period of peak juvenile salmon abundance (April to June).

On-land tailings disposal would double the loss of wildlife habitat, and additional habitat would be subject to construction disturbance, which would extend throughout project operations. Both Tunnel Creek and Aronitz Creek are at the edge of estuaries and, therefore, habitat of greatest value would be subject to long-term disturbance.

The tailings dams in Tunnel and Aronitz creeks would be visible from Wilson Arm and Boca de Quadra, respectively, and would introduce a massive, uniform, gray face at the valley entrances.

2.5.4 Housing Alternatives

The proposed project incorporates the commute option in which workers are housed at the mine and mill during on-duty days and transported to Ketchikan for off-duty days. Alternatives for housing workers include the townsite option and the phase-in option. Impacts in the vicinity of the project site caused by a townsite are additive to those described for the proposed project and other alternatives.

Proposed Project

The proposed project would have very significant socioeconomic impacts, both positive and negative. New employment related to the Quartz Hill project would be both direct and indirect, and would total approximately 1,750 new jobs at the peak construction level and approximately 2,000 new jobs during project operations. The population increase in the Ketchikan Gateway Borough (KGB) resulting from in-migrants would generate an increase in the volume of business for area firms. This would result in positive long-term benefits to local firms due to an increase in demand for goods and services. It would

also result in short-term price increases and an influx of new business establishments. The major population growth in the KGB would occur early in the project during construction and early years of operations.

Impacts on housing and land use could be very significant. Impacts associated with the increased demand for new housing could include potential problems in determining the types of housing needed, poor quality and substandard construction, shortages of and increased prices of temporary housing, and availability of financing. Housing prices could be particularly susceptible to increased demand and could result in increases in the cost of living.

Recreation facilities, schools, social services (including mental health services), ports and harbors, landfill, library, museum, and certain roads are currently stressed by the existing population and additional growth would exacerbate the problems. However, these services and facilities would need to be expanded regardless of the project. Other services including fire protection, law enforcement, streets, and water supply can meet current demand but would need to expand as the population grows. Although these improvements would be needed regardless of whether Quartz Hill is developed, the project would alter the timing and magnitude of the expansions required.

The major public service expenditures required to serve the project-induced population would be a new elementary school, playing fields, neighborhood and regional parks, additional streets and water and sewer lines, additional city and borough personnel and equipment, and, possibly, a new fire station.

Townsite Option

The townsite option involves the development of a full service community at the beginning of the project at one of several possible sites including Bakewell, Wilson I, Wilson IIa, and Keta. The townsite option would result in workers living in the immediate vicinity of the project with no regular commutes to Ketchikan.

Bakewell:

An access road to the Bakewell townsite would result in landslide hazards during construction in some very steep areas. Such hazards would diminish during operations. Avalanche hazards on some sections of the access road would exist during construction if work occurs during high hazard periods, and also during project operations when regular travel would occur on this road.

Long-term impacts from the town on freshwater fisheries would stem primarily from increased sport fishing. Fishing would probably be one of the primary recreational activities for residents. The townsite would also place residents with leisure time in the midst of hunting and trapping opportunities. The resulting hunting and incidental harassment would be the most significant impact on wildlife (especially mountain goats, bears, waterfowl, and furbearers) of any of the project

components. The incremental loss of wildlife habitat would also be relatively important because the townsite is at a low elevation near estuarine habitat.

The townsite option would involve two construction periods and an operations period. Most impacts to Ketchikan would occur during the first construction period when the townsite is being prepared. The work force requirements would be generally the same as for the proposed project, except that an additional work force averaging 200 and peaking at 250 would be required for townsite construction. During peak construction, the project would directly and indirectly provide employment for about 2,130 people. During operations, the total employment, direct and indirect, related to project operations would be about 2,000. During operations, approximately 450 jobs would be in Ketchikan with the remainder at the townsite and project site.

The types of impacts on local businesses in Ketchikan would be similar to those of the proposed project, but could be diluted by business activity that would occur at the townsite or that would bypass Ketchikan. A rapid period of population growth would occur when the pre-operations personnel would be living in Ketchikan. The number of newcomers would decrease later as a result of pre-operations personnel moving to the townsite.

The ultimate population expected at the townsite, including operations and secondary workers and their families, would be about 2,000. The population influx of 800 persons into the KGB would require additional permanent and temporary housing units. Most of the housing impacts would occur during the pre-operation period when a large number of units would be needed in a short time. Fluctuations in housing demands could cause vacancies in some types of housing. The types of impacts on housing supply, quality, and prices would be similar to the proposed project, but would be short term, with no further impacts after the townsite was complete.

The townsite option would increase the need for improvement of certain public facilities and services, although expansions would generally not be to the extent required with the commute option. These include recreation facilities, schools, social services, ports and harbors, library, landfill, museum, and transportation facilities. The townsite option would alter the timing and magnitude of expansion in public facilities and services. The major public service expenditures required to serve the project-induced population would be part of a new elementary school, playing fields, a neighborhood park, additional streets and water and sewer lines, additional city and borough personnel and equipment and, possibly, a new fire station.

Development of a townsite would have recreational effects throughout most of the Monument, and would result in very significant overall impacts to Monument use and values.

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Wilson I:

Most of the impacts of the Wilson I townsite would be of the same type as a Bakewell townsite. The following paragraphs describe the significant differences between the sites.

Landslide and avalanche hazards at Wilson I and its access road are lower than for the Bakewell townsite and its access road, and are expected to be insignificant. The Wilson I townsite could result in sediment load increases in the Wilson River that could affect salmon spawning habitat.

The Wilson I townsite is not compact, requiring two development areas with a vertical separation. The site would afford good access to the work place and allow views to the north, east, and west. Views to the south across Wilson Arm would be blocked. Negative aspects of the site include lack of exposure to sunlight in winter due to its northern exposure, and odors from decaying fish during the spawning season.

Wilson IIa:

The Wilson IIa townsite would have impacts similar to those of the Wilson I townsite except that Wilson IIa would allow access to both sides of the Wilson estuary, thus substantially increasing the potential disturbance to wildlife. This site would have many of the same attributes related to quality of life as the Wilson I site. Differences include a better exposure to sunlight, somewhat more limited views, and proximity to the floodplain.

Keta:

Many of the types of impacts of the Keta townsite would be similar to the other townsites, although the location of impacts would be shifted to the Keta River and Boca de Quadra from the Wilson Arm drainage. The townsite is within a short distance of several potential avalanche zones. The access road to the townsite also traverses several potentially major destructive avalanche zones. Personnel exposure to these hazards would be a very significant impact. The Keta townsite has limited suitable land and would necessitate a predominance of multi-family housing. The negative aspects include confinement between steep slopes, resulting in a windy site, minimal exposure to sunlight, talus deposits that could be a problem for adequate foundations, and avalanche hazards that would restrict movement of residents from November through May and could make traveling to the work place hazardous at times.

Phase-In Option

The phase-in option would involve the development, over a period of 4 to 6 years, of a full service townsite at any one of the locations described above. The phase-in option at any of the townsites would

have the same impacts as the townsite option, with additional socioeconomic impacts on Ketchikan during the 4 to 6 years of the phase-in, when workers would be commuting from Ketchikan to the project site.

All work force employment would be the same as for the proposed project, except that 100 workers would be required for a 4-year period to construct the townsite. A rapid period of population growth would occur in order to support start-up of the mine, since the operations work force and their families would be living in Ketchikan. Thereafter, population in the Ketchikan communities would be relatively stable because the transfer of workers to the Quartz Hill townsite would be offset by baseline population growth. A large number of temporary housing units would be needed in the Ketchikan communities to accommodate the workers and their families before they move to the permanent townsite. Some of the vacated units could be used to house baseline growth, but there would nevertheless be a substantial number of excess housing units.

The long-term needs for expansion of public services and facilities would be similar to the townsite option after the phase-in. Prior to the phase-in, the interim needs would be greater than for the townsite option. Interim needs could be met with temporary facilities, or with permanent facilities that could be used to accommodate baseline growth.

2.5.5 Wharf Alternatives

The proposed project includes a wharf on Wilson Arm near, but extending downfjord from, the location of the existing dock. Alternatives to this location include an adjacent upfjord location on Wilson Arm, and a Boca de Quadra wharf site. The latter wharf would be compatible with a North Meadow plant site and a Keta access road.

Proposed Project

The proposed wharf that would be constructed downfjord from the existing floating dock on Wilson Arm would not significantly affect the marine ecology of Wilson Arm.

Wharf Upfjord on Wilson Arm

This wharf location is adjacent to, but upfjord from, the location of the proposed wharf. Impacts to marine organisms from the upfjord wharf location would be greater than the proposed downfjord location. The area is slightly shallower and has greater potential of sedimentation from the Wilson delta. This site would require major filling to reach the necessary draft for barges. The facilities would be closer to high density juvenile salmon areas and any effects would have greater consequences.

Boca de Quadra Wharf

The types and magnitudes of impacts of a Boca de Quadra wharf would be similar to those of a wharf on Wilson Arm. Wharf-related impacts would be eliminated in Wilson Arm, and essentially transferred to Boca de Quadra.

2.5.6 Other Alternatives

Other alternatives include tailings transport tunnel and pipeline alignments, and diversion of upper Hill Creek.

Alternate Tailings Transport Alignments

Alternative tailings tunnel and surface pipeline alignments to the Boca de Quadra submarine tailings outfall have been examined, which could result in somewhat different impacts. These alignments are dependent upon the mill site selected. The following paragraphs describe alternate alignments for each mill site.

Tunnel Creek Mill, Tailings Tunnel:

If tailings disposal to the middle basin of Boca de Quadra at the start of the project is selected, a tunnel could be constructed directly to the middle basin discharge point. This would replace the tunnel to the inner basin and the submarine tailings pipeline extension to the middle basin that is addressed in 2.5.3 of this section. A tunnel alignment directly to the middle basin would eliminate any impacts to marine organisms from the underwater pipeline extension, including potential impacts resulting from a break of the submarine pipeline. The middle basin tunnel portal would be located a short distance into the wilderness area, and thus would require special consideration to be permissible.

Beaver Creek Mill, Tailings Tunnel:

If Boca de Quadra tailings disposal is selected with the Beaver Creek mill alternative, the tailings tunnel would consist of two segments connected by a surface pipeline at the head of Tunnel Creek. The Tunnel Creek to Boca de Quadra segment could be aligned to have a tunnel portal overlooking the Keta River estuary, with a surface pipeline to the inner basin, or be aligned to have its portal above the inner basin downfjord of the estuary. In either case, if a middle basin discharge is selected, an extension to the middle basin would be by submarine pipeline.

With a tunnel portal above the Keta River estuary, the potential exists for very significant water quality impacts in the lower Keta River in the unlikely event of a major tailings line break. These potential water quality impacts would be eliminated with a downfjord tunnel portal. A major spill of tailings into the Keta estuary would have very significant impacts on feeding juvenile salmon if it were to occur during periods of peak abundance (April-June). Important benthic

organisms, which are common food items, would be lost and salmon production decreased until organisms reestablished in the area. Vegetation and wildlife would also be affected.

North Meadow Mill, Tailings Pipeline:

A surface tailings pipeline from the North Meadow mill to Boca de Quadra would generally follow the access road. Moderately significant impacts on marine ecology, vegetation, and wildlife could result from effects on habitat along the Keta estuary. This would be a long pipeline that traverses terrain having high avalanche and landslide hazards. A major pipeline break, although unlikely, could occur, and would affect Hill Creek, the Keta River, the estuary, or the inner basin of Boca de Quadra.

Upper Hill Creek Diversion

Rather than allowing upper Hill Creek runoff to flow through the base of the waste rock disposal area, it could be diverted to North Creek. This would result in a reduction in flow in Hill Creek and increases in flow in North Creek. Diversion of upper Hill Creek flow would decrease the potential for leaching from the waste rock. Increased erosion and scouring of the North Creek streambed would occur until the channel stabilizes, and North Creek would be unsuitable for fish production during this period. Impacts on the Blossom River are expected to be insignificant, but could be very significant if slope undercutting on North Creek caused substantial landslides. After the channel stabilizes and habitat begins to recover, the increased streamflow may result in more fish habitat and fish production than was present before the diversion of upper Hill Creek. Mitigation of fisheries impacts on North Creek could include habitat reclamation. Reclamation of the approximately 2,500 ft reach of North Creek accessible to anadromous salmonids would likely cost less than $10,000.

The diversion of upper Hill Creek would not be needed until waste rock encroached on the Hill Creek stream channel some time after about year 15 of operations. At about this same time, pumping from the pit into White Creek would begin. This addition of water to the Hill Creek system would partly balance the loss from diverting upper Hill Creek.

2.6 COMPARISON OF COSTS OF ALTERNATIVES

2.6.1 Alternative Project Concepts

Comparative costs for the proposed project and the range of alternatives described in this section have been prepared by U.S. Borax. These costs are estimates of capital costs for the first 20 years of mine operation only. All costs presented are in second quarter of 1984 dollars. Table 2-3 presents the costs for the alternative concepts and the major components.

TABLE 2-3

CAPITAL COSTS FOR ALTERNATIVE PROJECT CONCEPTS

	ALTERNATIVE CONCEPTS (All Costs in Millions of Dollars)1/							
Plant Site:	Tunnel	Tunnel	Tunnel	Beaver	Beaver	Beaver	North Meadow	North Meadow
Tailings:	Boca(A)	Boca(B)	Wilson	Boca Inner	Wilson	Land	Boca Inner	Land
FACILITY								
Mine	190	190	190	190	190	190	190	--
Ore Transport	60	60	60	17	17	17	34	--
Conc/Ancillaries	259	259	259	285	285	286	288	--
Power Supply2/	83	83	83	84	84	87	87	--
Water Supply	21	21	21	41	41	23	41	--
Tailings Disposal	42	68	9	44	16	1,844	42	--
Subtotal	655	681	622	661	633	2,447	682	--
Contingency	57	57	57	99	95	367	102	--
TOTAL QUARTZ HILL CAPITAL COSTS4/	712	738	679	760	728	2,8143/	784	(5)

1/ Includes only initial Quartz Hill 20-year estimated costs in second quarter 1984 dollars, and not replacement equipment costs.

2/ On-site power plant.

3/ Land tailings figure developed for EPA was increased by 1 percent to change it from first quarter 1984 dollars to 2nd quarter 1984 dollars.

4/ Includes commute option.

5/ Total capital costs not developed. Extra costs are required beyond that needed for the Beaver plant site/land tailings disposal alternative. Therefore, the total cost would be greater than $2,814 million.

BOCA (A) - Inner Basin

BOCA (B) - Middle Basin, at sill

Source: U.S. Borax 1984f, 1985h; Envirosphere 1987.

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The primary differences in cost as shown in Table 2-3 are in ore transport, the concentrator and ancillary facilities, and tailings disposal. A Tunnel Creek mill site would have higher ore transportation costs ($60 million) due to the ore conveyor tunnel to Tunnel Creek, but lower concentrator/ancillary facility costs ($259 million) than other alternatives. Beaver Creek mill sites would have a capital cost of $285 million for the concentrator/ancillary facilities and $17 million for ore transport. Corresponding capital costs for a North Meadow mill site are $288 million and $34 million for the concentrator/ancillary facilities and ore transport, respectively.

Tailings disposal alternatives represent significant differences in cost and project schedule. They range from approximately $9.4 million and a construction schedule of 9 months for the Wilson Arm tailings disposal alternative to approximately $68.3 million and a construction schedule of 29 months for the middle basin of Boca de Quadra alternative with a tunnel directly to the middle basin.

In addition to the overall concept alternatives, a range of component alternatives have been identified and described earlier in this section. The following paragraphs provide the comparative costs for these alternatives.

2.6.2 Concentrator/Ancillaries

With the North Meadow mill site the mine access road would be constructed from tidewater up the Keta River and then up Hill Creek to the mill. The cost of a two lane access road to the mill site is expected to be $37.3 million (1984 dollars) for a route with wooden snow sheds in avalanche areas. Due to avalanche risks in seven areas along the route, large tunnels could be constructed to bypass these avalanche paths. These tunnels would add approximately $11 million to the cost of the road. After the completion of the Keta access road, the Blossom River route would be reclaimed. Reclamation of this road, including excavating and removing culverts to allow for open ditch drainage, removing bridges, removing other facilities, and seeding the road, would cost approximately $648,000.

2.6.3 Tailings Disposal

Alternative tunnel alignments have been identified for the marine disposal alternatives to Boca de Quadra. For the Tunnel Creek mill site with tailings disposal to the middle basin of Boca de Quadra throughout the life of the mine, a tunnel could be constructed directly to the middle basin. The cost of such a tunnel is estimated to be $68.3 million. The tunnel to the inner basin would cost approximately $42.0 million. An extension to the middle basin via a pipeline generally following the shoreline of Boca de Quadra would cost an estimated $9.4 million. As shown in Figure 2-3, an alternative alignment for the tailings tunnel from Beaver Creek has also been identified, which would result in a portal location below the Keta River estuary, rather than just above the estuary. The realigned tunnel from the Beaver Creek portal to the discharge location at Boca de Quadra would cost approximately $57 million. By comparison, the

alignment from Beaver Creek to the near-estuary portal would cost approximately $34 million for the tunnel and $10 million for the surface pipeline to the inner basin discharge location, a total estimated cost of $44 million.

2.6.4 Housing

The proposed project incorporates the commute option with the employees being housed at facilities at the mine and mill during their on-duty period and commuting to Ketchikan during their days off. The capital cost of this option is estimated to be $9.0 million.

Development of a full service townsite in the vicinity of the project is an alternative to the commute option. Development of a townsite at Bakewell is estimated to cost $134 million. The capital cost of a Wilson I townsite is estimated to be $112 million. No capital costs have been developed for the Wilson IIa or Keta townsite alternatives.

2.6.5 Water Supply

The proposed project includes Tunnel Creek as the primary water supply source with withdrawals from intake facilities on the Blossom River as a supplemental source. The feasibility of various scenarios or project arrangements for the preferred alternative were examined in detail in a report by Envirosphere (1987). Depending on the instream flow agreements and the size of the dam on Tunnel Creek, this report estimated the capital cost plus the first 20 years operating cost could range from $14.7 million to $50.4 million. The capital cost associated with the proposed project is approximately $21 million.

If the mill were located at the Beaver Creek site or the North Meadow site, other combinations of water supply sources would be required. Estimated capital costs for a water supply for each different mill site were compared in Table 2-3.

2.7 PREFERRED ALTERNATIVE

The preferred alternative for mine development is to locate the ore processing facilities in the Tunnel Creek valley, generate electric power for the mine on-site, not allow creation of a townsite, access the mine along the route of the existing bulk sample access road, and obtain processing water from an impoundment on Tunnel Creek.

When the mine production is increased from the initial 40,000 tpd capacity to 80,000 tpd, the water supply may be supplemented from a location near the mouth of the Blossom River. Water withdrawals from both Tunnel Creek and the Blossom River will be managed so that an instream flow is maintained sufficient for present and future productivity of fish habitat.

The Forest Service preferred alternative for tailings disposal is marine disposal in Wilson Arm/Smeaton Bay. The EPA concurs with the Forest Service preferred alternative. Impacts of the discharge will be evaluated through a monitoring program developed by the EPA in

conjunction with issuance of an NPDES permit for the tailings discharge. The monitoring is primarily intended to ensure that unreasonable degradation to the aquatic environment is not occurring. The NPDES permit will be designed to avoid exceedance of water quality criteria outside the mixing zone for the discharge. Depending on the results of the monitoring program, the permit for tailings disposal may be modified or even terminated if necessary prior to the completion of the design life of the project.

2.8 CUMULATIVE IMPACTS

The regulations for implementing NEPA (40 CFR 1508.7) define cumulative impacts to include "the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions . . ." In terms of past actions, the existing evidence of human habitation in the wilderness area surrounding Boca de Quadra is relevant. The existing features include an old cannery, a fish hatchery, and evidence of use by Indian cultures. The Boca de Quadra tailings disposal alternative would add to these existing features a highly visible tunnel portal, about 25 ac of disturbed area around the portal, and increased human activity associated with construction of the facility and later monitoring operations. The incremental impact of this activity on the wilderness area is one reason why this alternative is not included in the preferred alternative.

In terms of future actions, two reasonably foreseeable actions have been identified: the southeast Alaska transmission intertie and a log transfer facility.

Southeast Alaska Transmission Intertie

The Alaska Power Authority and various southeast Alaska communities for several years have expressed interest in building a transmission interconnection of southeast Alaska's major electric load centers and hydro generation resources. Importing power from Yukon Development Corporation and/or B.C. Hydro in Canada has also been considered.

The Power Authority recently completed an analysis of the intertie system (APA 1987), including systems studies, route selection, engineering studies, and economic analysis. Of 18 separate route segments studied, 3 involved interconnections to Quartz Hill, as follows:

1) Quartz Hill to Swan Lake (Segment 10) - Analysis of this segment included eight alternative routes. Each of the eight alternatives uses some combination of links between Swan Lake and Behm Canal, a submarine crossing of Behm Canal, and one of two links east of Behm Canal to the mine site.

   Overland Route: One link, referred to as the overland route, uses a submarine cable crossing Behm Canal and leaving the north shore of Smeaton Bay at Bartholomew Creek. The route is overland up the Bartholomew Creek drainage and across the

Wilson and Blossom Rivers before reaching the mine site. The alternatives using this link cross several miles of nonwilderness area within the Misty Fiords National Monument, but no wilderness area, after leaving Smeaton Bay. (They do cross some wilderness area--from 4.0 to 12.1 miles--between Swan Lake and Behm Canal.) In conjunction with the Quartz Hill project, use of this route would add to vegetation and wildlife impacts in the disturbed area, and cause some increase in the sediment load in the Wilson and Blossom rivers, particularly during construction. Impacts associated with on-site power generation would be greatly reduced, but not eliminated, by reliance on a transmission line for power. Scaled-down on-site generation would still be required to maintain essential equipment in the event of transmission line failure. On-site generation would not be sufficient to permit continued operation of the concentrator and mine during a power failure, however.

Submarine Route: The second link, termed the Wilson Arm submarine route, uses a submarine cable across Behm Canal and continuing underwater past Bartholomew Creek and remaining underwater through Wilson Arm as far east as Wharf Point. The route then follows the south shore of Wilson Arm overland and through the proposed Quartz Hill ore transport tunnel to the mine site. Alternatives using this link cross a few miles of nonwilderness area, and no wilderness area, east of Behm Canal. Like the previous alternatives, they do cross some wilderness area west of Behm Canal, between Swan Lake and the canal.

This link, with the submarine cable routed through Wilson Arm to Wharf Point, would be precluded by tailings disposal in Wilson Arm. It would be technically infeasible to have the cable located in an area of active tailings disposal, both because the cable could be damaged during the disposal activity and because the cable could become so deeply buried that it would not be accessible for repair. The most promising route using the Wilson Arm submarine option, and the route preferred from an engineering perspective, was not selected by the Power Authority as the overall preferred Swan Lake-Quartz Hill route. The best submarine option was eliminated from further consideration both because it was much more expensive than the overland route ($45.1 versus $38.8 million) and because of the uncertainty over Wilson Arm tailings disposal.

In the final analysis, neither the submarine route nor the overland route was included in the Power Authority's preferred transmission expansion plan. The preferred expansion plan includes no Swan Lake-Quartz Hill interconnection.

2) Quartz Hill to Prince Rupert (Segment 15) - Routes analyzed for this segment connecting Quartz Hill to B.C. Hydro at Prince Rupert would be located underwater predominantly, but

would use the overland route described above from Smeaton Bay to the mine site. This is the only route studied that crosses no wilderness area, but it includes several hazards in the submarine environment. This connection was rejected by the Power Authority in favor of Segment 11 (see below) because Segment 11 has a considerably lower cost and presents fewer technical difficulties than Segment 15.

3) Quartz Hill to Kitsault, B.C. (Segment 11). This route is the only interconnection to Quartz Hill included in the Power Authority's preferred expansion plan. The route uses neither the overland nor Wilson Arm submarine routes described above. Instead, it follows an alternate overland route from Kitsault, B.C., crossing approximately 17 miles of Misty Fiords National Monument Wilderness Area. The route was preferred by the Power Authority because of its technical and cost advantages over the alternative connection to Prince Rupert.

In summary, several electrical transmission alternatives have been studied by the Alaska Power Authority to link Quartz Hill with Swan Lake and/or Canada. With respect to the Quartz Hill project, key findings include the following:

- A transmission line following any of the routes would greatly reduce the impacts associated with on-site power generation, although emergency generation capabilities would still be required.

- All routes but one (Quartz Hill to Prince Rupert) cross some portion of the Misty Fiords National Monument wilderness area. All the routes cross some portion of the nonwilderness area. Use of any route would create both terrestrial and marine impacts, including visual impacts, increased sedimentation, habitat disturbance, and (with the exception of the Prince Rupert route) impacts on wilderness values.

- Tailings disposal in Wilson Arm would increase the terrestrial impacts associated with the routes from Quartz Hill to Swan Lake and/or Prince Rupert by precluding location of a submarine cable in Wilson Arm/Smeaton Bay, and forcing use of an overland route through the nonwilderness portion of the national monument.

Log Transfer Facility

A temporary log transfer facility was formerly included in the U.S. Borax Quartz Hill application to the Army Corps of Engineers (see RDEIS Appendix P). The facility is no longer included in the application but will be considered later in a separate licensing process. Its environmental effects are considered here, however, in the event the log transfer facility is needed later on. This analysis does not preclude further environmental study at the time of permit application.

The temporary log transfer facility (LTF) would be constructed and operated on the ramp of the existing wharf facility in Wilson Arm during the land clearing phase of plant and terminal construction. The LTF would consist of log cribbing and skid logs located on the existing rockfill ramp. The log bundles, delivered to the landing by log truck, would be rolled off the truck, pushed down the skid logs, and floated off at high tide. They would then be transferred to a stiff leg boom for storage. The boom used for log storage would be the same boom associated with the temporary floating work camp.

At the start of project construction, there will be a need to clear timber from the facility sites such as the marine terminal, roads, process plant site, water supply reservoir, and mine site. Any cleared timber of commercial value could be hauled to the log transfer facility for storage and eventual resale. During the initial construction phase, the volume of commercial timber to be moved over the log transfer facility would be 3 to 5 million board feet. Upon the planned expansion of the facilities in years 4 to 6 of operations, another estimated 1 to 2 million board feet would be transferred over this facility.

Log transfer and rafting is a common practice in southeast Alaska, where there are currently 90 active log transfer sites and 49 log storage areas (Faris and Vaughan 1985). Most of these sites handle larger quantities of logs than the proposed Quartz Hill site.

Log transfer and rafting have been found to cause reduction in benthic fauna in some areas of southeast Alaska (Pease 1974). This reduction was caused possibly by leachate from bark, shading of the bottom, reduced oxygen, or changes in the substrate composition. In another study, the only reduction in benthic taxa was found in areas of negligible water movement (Schaumberg 1973). Bottom compaction from log storage in an intertidal area has been found to be the most severe effect in some studies (Oregon DEQ 1979).

The transfer of logs at the Quartz Hill site is likely to cause some increase of bark covering the bottom. Based on studies at eight sites in southeast Alaska (Pease 1974), this area would be within a 50-75 ft radius of the transfer point. The transfer sites studied by Pease were all large, ranging in size from 7 to 550 million board feet and averaging 140 million board feet in a facility life of 1 to 10 years. Thus, most were much larger than the proposed site at Quartz Hill.

Pease (1974) observed significant reduction of benthic infauna at only one of the log rafting sites he studied. This site apparently had been impacted by the grounding of logs during low tide. He found no effect on epifauna in transfer or storage areas. He also conducted bioassays on pink salmon from log leachate and found it to be toxic, but concluded that fish would have to remain in close contact to logs for extended periods to be affected.

Even though some characteristics of log transfer and storage have been found to cause some negative environmental effects, the characteristics of the proposed Quartz Hill site should result in no significant impacts within Wilson Arm. An area of the bottom less than 50-75 ft from the transfer point will have an increased covering of bark. Because this is a rock-filled barge loading area, changes to the natural bottom area will be small. The entire area affected, including the ramp, should be less than 0.1 ac. The log rafting area is small (1.4 ac maximum). Log rafts will be located in deep water off of the bottom at all times. This will prevent grounding. The head of Wilson Arm is not considered stagnant, so flushing will occur around the log rafts and bottom bark, eliminating any accumulation of potentially toxic leachate.

3.0
AFFECTED ENVIRONMENT

3.0 AFFECTED ENVIRONMENT

This chapter addresses the environmental components affected by the proposed project or alternatives. Environmental components not affected by the project are covered briefly or are not covered; therefore, this chapter is not intended to present a complete characterization of the existing environment of the project area.

3.1 PHYSICAL ENVIRONMENT

3.1.1 Meteorology, Climatology, and Air Quality

Project Area Meteorology and Climatology

On-site meteorological monitoring began in 1976 with the installation of a precipitation station at the Quartz Hill campsite. A total of 10 weather stations to monitor wind patterns and precipitation were installed in 1978-1979. A meteorological station at Tunnel Creek and high volume particulate samplers at Tunnel Creek and the mine site were installed in June 1983 (VTN 1983k, Section 1.1.2).

Temperature, rainfall, snowfall, and wind patterns in the project area are all influenced by topography. At sea level, mean monthly temperatures ranged from 20°F in January to 56°F in July. At the mine site, mean monthly temperatures ranged from 19°F to 54°F.

In general, annual precipitation increases with elevation, although significant rain shadows have been observed at some locations. The period 1977-1982, during which time precipitation measurements at Quartz Hill were taken, was unusually dry along the entire southeast Alaska region. During that period the measured annual precipitation (rainfall plus snow water equivalent) at five on-site stations ranged from 76 to 119 inches. Mean monthly rainfall at the mine site ranged from 5.4 inches in June to 20.6 inches in October. The highest recorded 24-hr and monthly rainfall rates were 5.7 inches (October 11, 1977) and 35.1 inches (October 1977), respectively. However, streamflow data taken since 1977 indicate that the total runoff from the mine site watersheds is equivalent to a precipitation rate much higher than that measured by the on-site meteorological stations. This indicates that orographic effects could create very high precipitation rates on the ridges surrounding the mine site. Similar discrepancies between streamflow and precipitation data have been observed at other southeast Alaska locations (VTN 1983l, p. 21). At Quartz Hill the ratio of surface runoff flow rate to drainage area is roughly 11.2 cfs/mi^2 during a normally wet year (see Appendix D, Surface Water Hydrology). This corresponds to 152 inches of annual runoff within the drainage basins. The calculated total annual precipitation rate over the Quartz Hill area ranges from 150 to 157 inches.

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Snow measurements were taken at three locations during the winters of 1977-79 and 1979-80 (Wilson 1980). During that period, measured snowfall at other southeast Alaska sites was below normal. Snowfall is expected during nine months of a normal year, and snow is expected on the ground from November through June. During the winter of 1978-79 the measured snowfall at the mine site was 556 inches (56 inches water equivalent). The maximum snow depths at the Keta River (sea level) and the mine site (1,380 ft) were 84 inches and 152 inches, respectively. During that winter the measured snowfall at other southeast Alaska locations was only 63 percent of normal (Wilson 1980, p. 7). The expected normal snowfall at the mine site is approximately 400-800 inches.

Wind patterns are governed by topography. Wind roses for the Blossom River, Keta River, and the mine site were developed during the baseline environmental study (VTN 1982a, Appendix A). Wind roses for Tunnel Creek are shown in Appendix C of this document. In general, winds in the river valleys (Blossom River, Keta River, Tunnel Creek) result from wind drainage up or down the valleys. Prevailing valley wind speeds during the winter averaged 8.2 mph. During the summer, prevailing valley wind speeds averaged 3.5 mph. In the broader, U-shaped creek valleys (Beaver Creek and possibly upper White Creek), weak drainage winds are generally dominated by the stronger prevailing winds measured in the intersecting river valleys. Thus, the prevailing winds in Beaver Creek blew across the valley in the same direction as the Blossom River wind. The prevailing cross valley wind speeds during the winter and summer of 1982 were 11.0 mph and 3.8 mph, respectively.

Near the mine site, winds were influenced by both the Beaver Creek and White Creek air basins. During the summer, prevailing winds blew from Beaver Creek at an average of 5.9 mph. During the rest of the year, prevailing winds were from White Creek at an average wind speed of 7.0-8.0 mph. Significantly, during fall the mine site experienced over 40 percent calm periods. Recorded wind speeds were very low at the Bakewell townsite station. Prevailing winds blew down the Falsegate Creek valley. However, the Bakewell site experienced over 36 percent calm periods during summer and fall.

Atmospheric stability factors (which indicate the potential for pollutant dispersion) were measured at the mine site and Tunnel Creek (VTN 1982a, Appendix B; Appendix C, this document). At the mine site, classes E and F (poor dispersion) occurred 28 percent of the time, during periods of northeasterly winds. At Tunnel Creek, classes E and F occurred 34 percent of the time, during periods of low speed easterly winds, averaging 1.7 mph. Stability classes A and B (good dispersion) occurred 22 percent and 31 percent of the time at the mine site and Tunnel Creek, respectively.

Air Quality

Applicable Alaska air quality regulations and standards are discussed in Appendix C. The project area and Misty Fiords National Monument are designated as Class II under the Prevention of Significant Deterioration (PSD) Program. Ambient air quality regulations for the area are specified under 18 Alaska Administrative Code, Chapter 50.020. The region is classified as an "attainment" area for all pollutants. The measured particulate matter concentrations at Tunnel Creek and the mine site during 1983 averaged 5.69 and 3.95 micrograms per cubic meter ($\mu g/m^3$), respectively (VTN 1983c, Section 1.0). No on-site background measurements for other pollutants have been conducted. However, the Quartz Hill site is located far from any existing air pollution sources, and the following background pollutant concentrations have been assumed: sulfur dioxide-2.0 $\mu g/m^3$; nitrogen oxides-2.0 $\mu g/m^3$; carbon monoxide-575 $\mu g/m^3$. The sulfur dioxide and nitrogen oxide values are based on measurements in other pristine locations (EPA 1981, Sec 5.2.2; EPA 1979a, Sec 8.1.1). The carbon monoxide value is a conservatively high estimate, and represents the threshold concentration limit for PSD monitoring requirements (EPA 1980a, Table A-3).

3.1.2 Geology/Soils

Geology

The project area is bounded by the Wilson River and Wilson Arm of Smeaton Bay to the northwest and the Keta River and Boca de Quadra to the southeast. Both the Blossom River and the Keta River flow in a southwesterly direction into Wilson Arm and Boca de Quadra, respectively. Wilson Arm and Boca de Quadra are typical glacial fjords characterized by steep side walls and sills of glacial origin, creating an uneven bottom configuration that effectively separates the fjord from the ocean.

Elevations in the area range from sea level at the fjords to over 4,000 ft at the highest ridges. Quartz Hill is 2,695 ft above sea level and is surrounded by ridges generally over 3,500 ft in elevation. Present landforms exhibited in the area are the result of extensive modification of preexisting bedrock during the Pleistocene glaciations. Most of the hilltops and ridges are rounded and characterized by exposed rock with glacial grooves. The Blossom and Keta rivers exhibit features characteristic of glacial valleys, U-shaped valleys with flat valley floors, and steep side slopes. Glacial cirques and lakes are evident at the heads of some streams in the area.

The project area lies near the western edge of the Coast Range batholith, a 50-mi-wide rock body that trends along the U.S.-Canadian border. The Coast Range batholith is composed mainly of granodiorite,

but includes quartz monzonite, quartz diorite, and pegmatite. The Mesozoic/Paleozoic Age rocks lie to the west and consist of metamorphosed sedimentary and volcanic rocks (Sanders 1983, p. 1-2).

The geologic units encountered in the Quartz Hill area from the Paleozoic Era to the Quaternary Period are presented in Table 3-1. The oldest rocks are the metamorphosed sedimentary and volcanic rocks of Mesozoic/Paleozoic Age. These rocks, referred to as paragneiss, exhibit a banded or gneissic appearance and occur in large areas to the northwest and southeast of Quartz Hill (Figure 3-1).

Underlying most of the project area are the granitic rocks of the Coast Range batholith (Figure 3-1). These rocks exhibit a range in composition from diorite, quartz diorite, and granodiorite to quartz monzonite and pegmatite that usually display the same lineation, strike, and dip. The Coast Range granitics outcrop along Hill Creek to the northeast and North Ridge (Sanders 1983, p. 1-3).

The relatively large Mt. Kendall quartz monzonite stock to the northeast of the site intruded the Coast Range batholith. The mid-Tertiary Travis stock and Quartz Hill stock intrude both the paragneiss and the Coast Range batholith. These stocks consist of quartz and sodium rich monzonites and are the source and primary hosts for molybdenum mineralization (Forest Service 1981, p. 3-8). Molybdenite is the most common molybdenum mineral and is the only mineral of economic importance at Quartz Hill (Sanders 1983, p. 1-6). Pyrite (FeS_2) is common throughout the area. Data on mineral percentages in the area are presented in EIS Appendix A, Tables II-1 and II-6. Trace amounts of other minerals (copper, lead, and zinc) have been determined by assays (Bechtel 1983a, p. A-3). The Travis stock underlies an area to the south of Quartz Hill in the upper portion of Tunnel and Back creeks. The Quartz Hill stock underlies Quartz Hill and extends northward to Bear Meadow.

Surficial geologic deposits consist of alluvium, colluvium, and glacial deposits. Alluvium occurs in the valleys of Wilson, Blossom, and Keta rivers and major creek valleys. Glacial drift was deposited in many areas as a thin veneer. Thicker deposits of glacial material occur in upland valleys (Sanders 1983, p. 1-5). Throughout Holocene time colluvial materials accumulated on or at the foot of slopes (Clay 1983, p. 2).

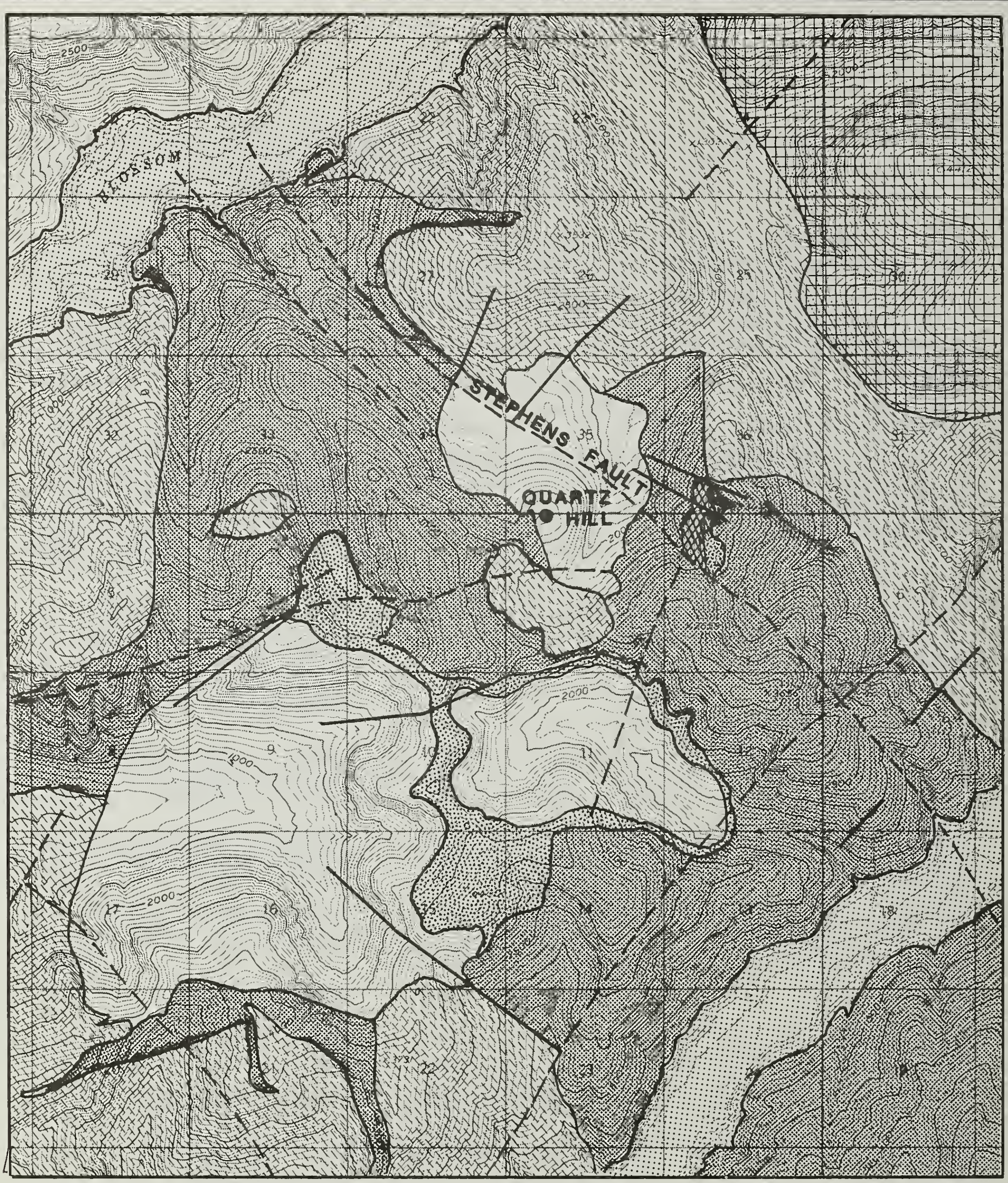
Structure and Tectonics:

The Quartz Hill area is located on the North American Tectonic Plate approximately 160 mi northeast of the boundary of the North American and the Pacific plates. The boundary is along the Fairweather-Queen Charlotte fault zone. Movement along the boundary is right lateral strike slip; the Pacific Plate is moving in a northwest direction relative to the North American Plate.

TABLE 3-1

GEOLOGY SUMMARY

Era	Period	Surficial Deposits	Lithology
CENOZOIC	Quaternary	Glacial sediments alluvium	Till - drift
	Tertiary	Intermediate dikes	Black to medium gray diabase, diorite, and quartz feldspar porphyry 4" to 32' thick
		Quartz latite dikes	Nearly white quartz latite 2' to 66' in width believed associated with the Travis stock
		Quartz Hill stock	Quartz rich porphyritic quartz monzonite
		Travis stock	Quartz rich porphyritic quartz monzonite
		Travis aplite	Fine grained quartz monzonite
		Intermediate dikes	Same as above - truncated by Travis stock
	Tertiary	Mt. Kendall stock	Quartz monzonite
MESOZOIC	Cretaceous	Coast Range batholith	Diorite, quartz diorite, and granodiorite to quartz monzonite
	Jurassic		
	Triassic	Paragneiss	Metavolcanic and metasedimentary, locally quartzite and calcareous metasediments (marble)
PALEOZOIC	No rocks of this age occur in the project area		



LEGEND

Superbreccia

Coast Range Granitics

Alluvial deposits

Travis and Quartz Hill Quartz Monzonite

Travis Aplite

Paragneiss

Quartz Latite

Kendall Quartz Monzonite

Contact

Fault

0 — 1 Mile

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RECONNAISSANCE GEOLOGY
OF THE QUARTZ HILL

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FIGURE
3-1

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The primary structural grain in the Quartz Hill area trends northwest-southeast, reflecting the overall structural grain of southeast Alaska (Sanders 1983, p. 1-7). The Stephens Fault is the dominant structural feature in the project area (Figure 3-1). The fault strikes N50°W and dips about 75° to the northeast. The fault cuts across the project area running northwest from the Keta River to the Blossom River and passing just to the north of Quartz Hill. The fault trace is marked by a 20- to 40-ft-wide zone of gouge and sheared rock. At least 600 ft of right-lateral offset has been reported. An undetermined amount of vertical slip has occurred, with the northerly side being thrown downward (Sanders 1983, p. 1-8). Although the Stephens Fault reflects the orientation of active faulting in the region, evidence of movement within the last 10,000 years has not been observed (IECO 1981, p. S-2). There are several smaller faults in the Quartz Hill area that are roughly parallel to the Stephens Fault (Figure 3-1). Several creeks in the project area, principally those tributary to the Blossom and Keta rivers, coincide with the same structural direction as the Stephens Fault.

Soils

The soils in the Quartz Hill region have generally formed from steeply sloping igneous parent rock with boreal forest and muskeg vegetation in a cool maritime climate. The relatively short period of time for soil formation, since the end of the Fraser Glacial episode approximately 7,000 to 10,000 years ago, and steep topography have resulted in generally shallow and coarse grained soils.

The cool wet climate of the project area, in which precipitation consistently exceeds evaporation, results in an excessively leached soil with low pH and low fertility. The relatively rapid cycling of the vegetation adds large amounts of organic matter to the soil, while cool temperatures and the low pH slow the decay of this organic matter. Sphagnum moss is the dominant species under these conditions. As it develops layer on layer, pH continues to drop, soil, saturation increases, and oxygen becomes more limited. The muskegs continue to impede drainage, leading to their further enlargement (Clay 1983, p. 4). The large organic component of the soil influences the distribution of elements and nutrients within the soil profile. The organic component has a very high water holding capacity, supplies the bulk of the nutrients within the soil system, and is also the predominant source of cation exchange capacity (CEC) and hence fertility in the soils in the study area (Clay 1983, p. 4).

The study area soils are typically noncohesive and can be slide prone when saturated (Forest Service 1982a, p. 3-5). The large numbers of plant roots within the soils provide a stabilizing influence on the relatively steep slopes.

Nine soil taxa were identified in the project area, seven of which are recognized soil series (Clay 1983, pp. 4-5). The two most commonly encountered soil series are the organic Kogish and McGilvery. The Kogish series represents muskeg soil and is typically uniform in soil properties in the study area. McGilvery series soils are found in steeper regions of well drained forest and exhibit greater variability in chemical, physical, and field properties than the Kogish soils (Clay 1983, p. 8). The remaining organic soils, Sunnyhay series, Kina series, and an undefined alpine soil composed mainly of partially decayed sphagnum, are less commonly encountered in the study area. In general, organic soils are the dominant surficial materials in the study area (VTN 1983d, p. 3-3).

The mineral soils exhibit a higher degree of variability in soil properties than the organic soils. These soils are represented by the Tolstoi series, the Tokeen series, the Tonowek series, and an undefined soil.

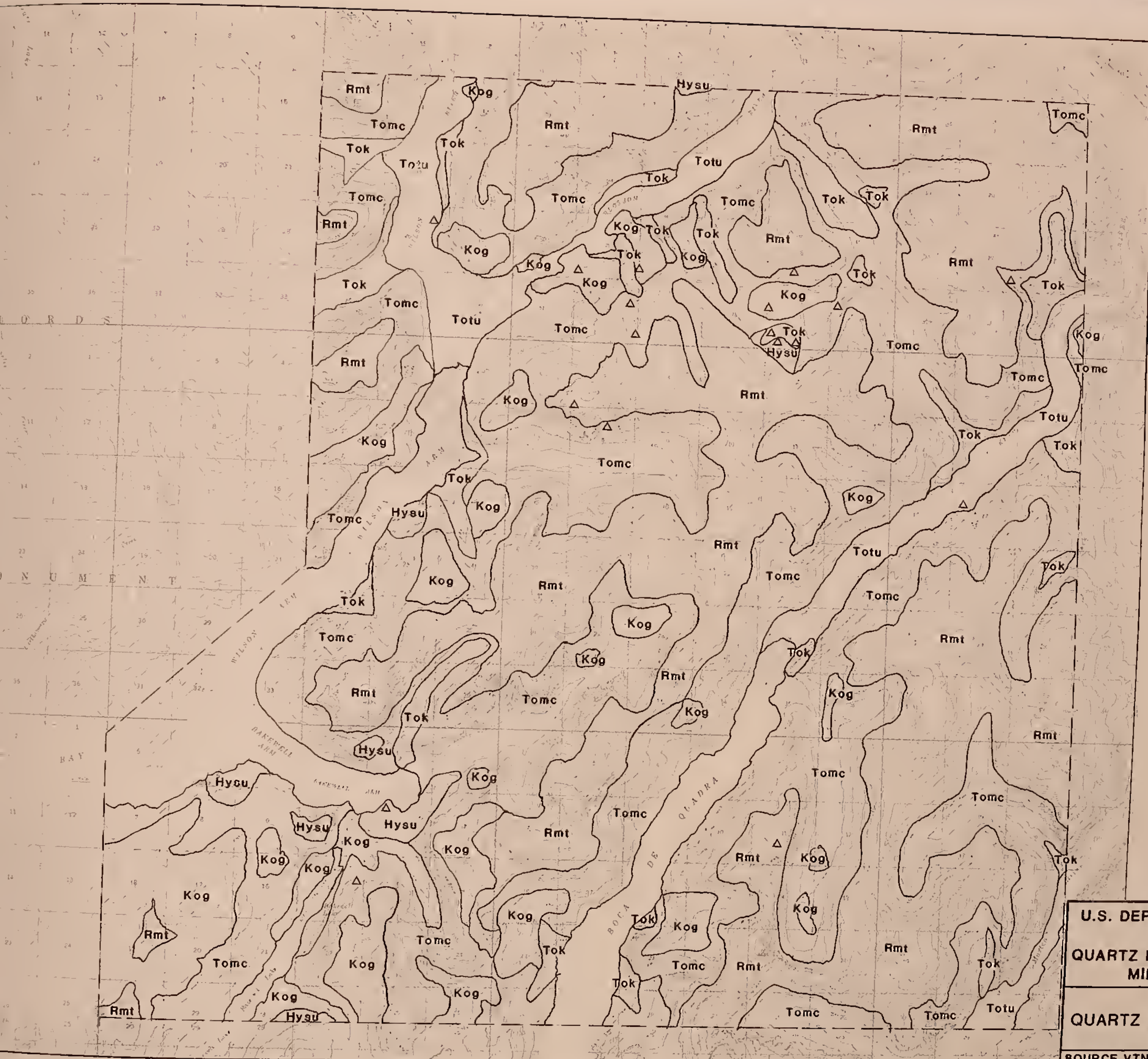
Mapping Unit Descriptions:

Figure 3-2 delineates the soils of the project area. For mapping purposes, the soils have been mapped as areas of predominantly one soil or landtype (e.g., Kogish peat, Rocky Mountainous Land) or areas of intermixed soil types (e.g. Tolstoi-McGilvery complex). Table 3-2 presents a summary of the characteristics of the mapping units.

Rocky Mountainous Land - This mapping unit is not technically a soil but is considered a miscellaneous land type, and may contain small pockets of organic soil. Rock outcrops are common and soil material, where found, tends to be very shallow. At lower elevations this mapping unit may include small portions of Sunnyhay soils (Clay 1983, p. 7).

Tolstoi-McGilvery Complex - McGilvery soils appear to dominate the mapping unit; Tolstoi soils are encountered less frequently. This mapping unit may include small amounts of rock outcrops, Sunnyhay, Kogish, Kina, and Tokeen soils (VTN 1982a, p. 19). Associated physiography consists of steep slopes, benches, glacial valleys, and concave slopes. Soil fertility is relatively high (Clay 1983, p. 8).

Kogish Peat - This mapping unit is composed of predominantly Kogish series soils, with significant inclusions of Kina series. It is typically found on level to hummocky or benched terraces, on valley floors, and on level benches where topography tends to impede drainage. Kina series within the mapping unit tend to be associated with shallow muskegs and glacial drift material and are often found at higher elevations where depth to granitic or intermediate composition parent material is shallow. Kogish series are most extensive in low lying regions (Clay 1983, p. 9). The soils are almost always saturated. Landslide potential and erosion hazard is slight due to gentle slopes (VTN 1982a, p. 20).



LEGEND

Rmt	ROCKY MOUNTAINOUS TERRAIN
Tomc	TOLSTOI McGILVERY COMPLEX
Kog	KOGISH PEAT
Tok	TOKEEN GRAVEL
Totu	TONOWEK - TUXEKAN
Hysu	HYDABURG - SUNNYHAY ASSOCIATION

N

0 1/2 1 2 3 4

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QUARTZ HILL PROJECT AREA SOILS

SOURCE VTN (82), CLAY (83) DATE OCT 83

FIGURE 3-2

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TABLE 3-2

QUARTZ HILL PROJECT AREA SOILS

Mapping Unit	Percent of Project Area	Depth[1/]	Permeability[2/]	Slope (percent)	Parent Material	Landslide Potential	Erosion Hazard	Topographic Setting	Soil Type
Rocky Mountainous Land	30	Shallow	-	0-75	Residuum and Colluvium	Moderate to high	-	Ridgetops, steep sided slopes, cliffs, and outcrops	-
Tolstoi-McGilvery Complex	35	Shallow	Rapid to moderately rapid	35-75	Colluvium and Organic	Moderate	Moderate	Shallow to moderately steep forested slopes and upland valleys	mineral organic
Kogish Peat	15	Moderate to very deep	Low	0 - 15	Organic	Slight	None to slight	Lowlands and muskeg areas	organic
Tokeen Gravelly Loam	12	-	Moderate	35-50	Colluvium and Residuum	Moderate to high	High	Moderately steep to steep slopes, valley and streambed sides	mineral
Tonowek and Tuxekan Soils	6	-	Moderately rapid to rapid	0-15	Alluvial material	Low	Low	Nearly level to sloping alluvial fans and terraces	mineral
Sunnyhay Soils	2	Shallow	Poor	35-50	Organic	Low	Moderate	Moderately steep to steep shoulders and upper back slopes of hills and valley sides	organic

1/ Depth Classification

	Ranges in Limits (in.) Upper	Lower
Very Shallow	0	5-10
Shallow	5-10	20-30
Moderately Deep	20-30	30-50
Deep	30-50	50-60
Very Deep	50-60	60+

2/ Very slow - 0.05 in./hr; slow - 0.05 to 0.20 in./hr; moderately slow - 0.20 to 0.80 in./hr; moderate - 0.80 to 2.50 in./hr; moderately rapid - 2.50 to 5.00 in./hr; rapid - 5.00 to 10.00 in./hr; very rapid - +10.00 in./hr.

Source: VTN (1982a).

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Tokeen Gravelly Loam - This mapping unit is most abundant in lower elevation areas and more commonly encountered in broader U-shaped valleys where residuum and alluvium have collected. These soils are well drained with moderate permeability. They may include pockets of other soil series including Tolstoi, Kina, Kogish, and others (VTN 1982a, p. 21). Landslide potential is moderate to high due to steepness of slopes, thixotropic soil properties, and low cohesion (VTN 1982a, p. 21).

Tonowek and Tuxekan Soils - The Tonowek and Tuxekan soils are deep and moderately well or well drained. These soils formed as a result of a series of depositional flooding events followed by weathering processes. Tonowek is the dominant soil in the mapping unit and is found in alluvial drainages. The Tuxekan soil is also found on alluvial fans and older, higher terraces (VTN 1982a, p. 21).

Sunnyhay Association - This mapping unit is found overlying bedrock at shallow depths. This mapping unit may include Tolstoi and McGilvery soils. It is also found in isolated pockets within the high elevation Rocky Mountainous Land mapping unit (VTN 1982a, p. 22). Drainage and permeability are poor and the soils tend to be saturated most of the time.

3.1.3 Surface Water Hydrology

The ore body is located on the divide between the Blossom and Keta river systems, which flow into the Wilson Arm of Smeaton Bay and the Boca de Quadra fjord, respectively (Figure 1-1). Within the Blossom River system, potentially affected streams include the Blossom River, Beaver, Raspberry, No. 1, No. 3, and North creeks; streams within the Keta River system include the Keta River, White Creek, Hill Creek, and two unnamed tributaries. Project facilities would also potentially affect the Wilson River downstream of its confluence with the Blossom River and Tunnel Creek, both of which drain directly into Wilson Arm, and Aronitz Creek, which discharges directly into Boca de Quadra. Numerous additional unnamed tributaries and intermittent streams would also be potentially affected.

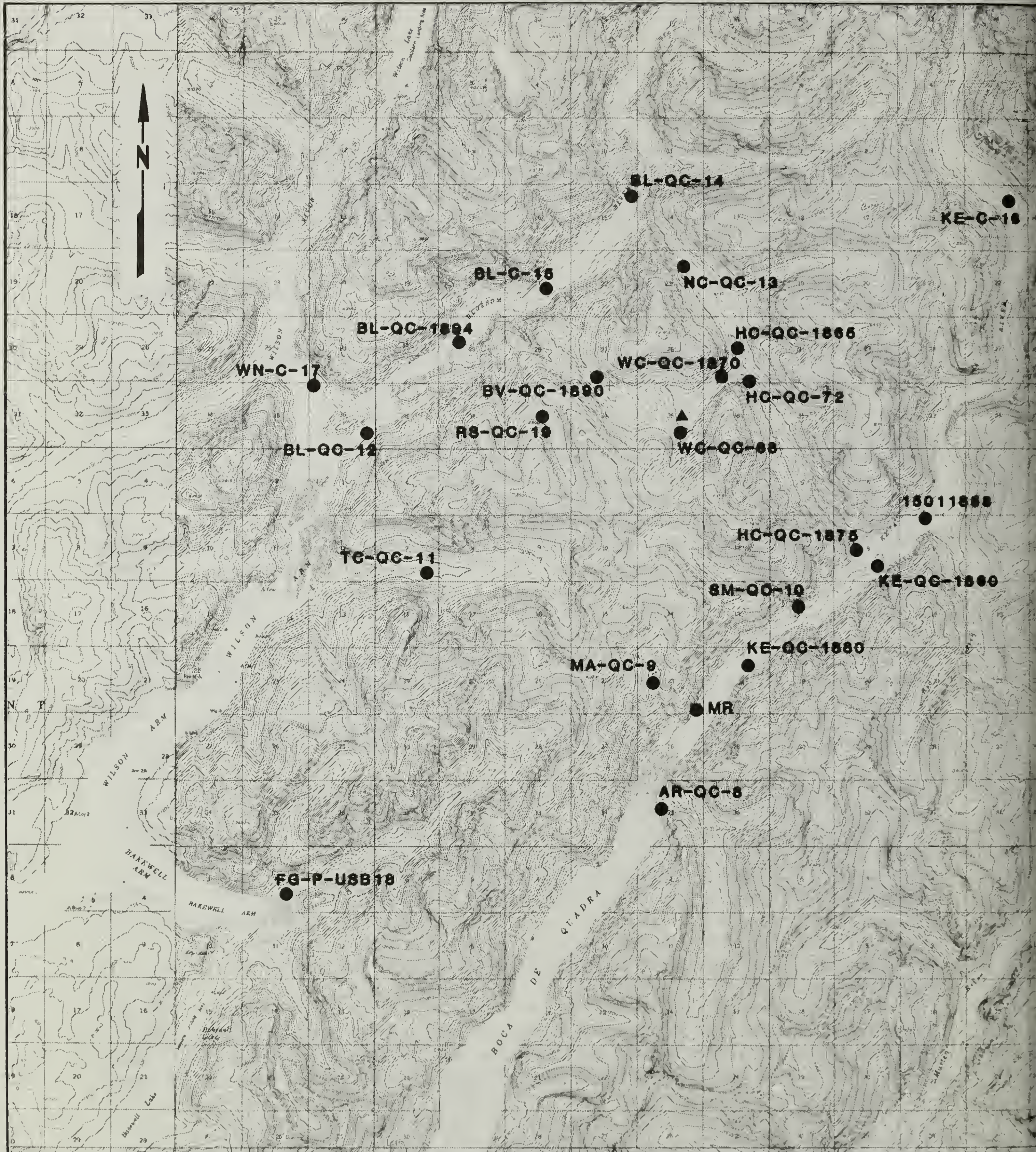
The Keta and Blossom rivers have small permanent snow fields of 0.03 square miles (sq mi) and 0.20 sq mi, respectively. These snow fields do not significantly affect streamflow patterns. With the exception of Wilson Lake, located several miles upstream of the Blossom River confluence, no lakes regulate streamflows in the project area. Numerous beaver ponds are located in the upland reaches of Beaver Creek, and muskeg dominates portions of the drainage area of many smaller streams. Muskegs behave as an impervious surface when the water table is at the surface, as is the case during high flow periods of spring and fall. When the water table is below the surface during drier periods in late summer, muskegs represent detention storage and can slow rainfall response somewhat.

Streamflow was measured continuously until October 1983 in the Keta River and White Creek from 1977, in the Blossom River from 1981, and in Tunnel Creek from 1982 (VTN 1983a, Section A-1). Instantaneous discharge has been measured in most of the potentially affected streams at selected times between 1976 and 1983. Crest stage gages have recorded peak flows in White, Hill, Beaver, Raspberry, and Tunnel creeks, and Keta and Blossom rivers since 1981 (VTN 1981g). Streamflow gaging station locations are shown in Figure 3-3.

Average annual streamflows measured in White Creek and Keta River for water years 1977 through 1982 (the longest on-site period of record) were 27.5 cfs (10.2 cfs/mi^2) and 768 cfs (10.4 cfs/mi^2), respectively. Long-term streamflow records in southeastern Alaska indicate that this period exhibited lower than average streamflows. Records from Fish Creek, the closest long-term station with a record that overlaps those of the project area stations, showed streamflows from the period 1977 to 1982 to be 10 percent below the long-term average annual flow (see Appendix D). Although the Fish Creek basin contains numerous lakes, these would not affect average annual flows, assuming no significant change in year-to-year storage. Long-term average annual flows for White Creek and Keta River were therefore assumed to be 10 percent higher than the recorded flows for 1977 to 1982, or 11.2 cfs/mi^2 and 11.4 cfs/mi^2, respectively. Average annual flows for all other site area streams were developed based on these runoff ratios and are presented in Table 3-3. Although runoff ratios for individual stream basins will vary due to rain shadow effects and differences in topography and basin aspect, this approach was assumed to provide a good estimate of average annual flows.

Seasonal flow patterns in the project area and in the region exhibit two high and two low flow periods annually. Highest flows generally occur during September through November when precipitation is high and temperatures are still above freezing. Lowest flows occur in February when nearly all precipitation is stored as ice and snow. Spring snowmelt causes secondary high flows in May and June, and low precipitation results in secondary low flows in August. The seasonal flow patterns for White Creek and Keta River are shown in Figure 3-4. Monthly flows estimated for each project stream are tabulated in Appendix D.

Streamflow records in the project area are not sufficiently long to perform statistical frequency analyses for low flow events (Riggs 1972, p. 8). In addition, long-term records in the region for stream basins of similar characteristics and with overlapping streamflow records do not exist (VTN 1980a, p. 10). Regression equations developed for southeastern Alaska were used to estimate low flows (Forest Service 1980a, Appendix A). Results are presented in Table 3-3 for the 7-day, 10-year low flow. Because low flows usually consist of groundwater discharge, low flows are highly dependent on basin geology, elevation, and geometry, and regional estimates can only be considered



LEGEND

● SURFACE WATER STATIONS

▲ QUARTZ HILL CAMP

0 1 2 3 4

SCALE - MILES

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

SURFACE WATER
MONITORING STATIONS

SOURCE VTN (1983a) DATE JUN 83

FIGURE 3-3

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TABLE 3-3

FLOW CHARACTERISTICS OF PROJECT AREA STREAMS

Drainage Basin	Drainage Area (mi^2)	Average Annual Flow (cfs)[1/]	7-day, 10-yr Low Flow (cfs)[2/]	10-yr Peak Flow (cfs)[2/]	100-yr Peak Flow (cfs)[2/]
Aronitz Creek (at mouth)	9.84	110	3.7	2,220	3,080
Beaver Creek (at sed. pond)	2.11	24	0.5	541	749
Beaver Creek (at mouth)	2.58	29	0.6	742	1,010
Blossom River (at mouth)	72.87	831	48.0	13,100	18,500
Hill Creek (at water supply res.)	3.06	34	0.8	694	972
Hill Creek (at sed. pond)	12.21	137	4.8	2,660	3,720
Hill Creek (at mouth)	14.42	162	5.8	3,230	4,490
Keta River (at mouth)	78.20	891	52.6	14,500	20,400
North Creek (at mouth)	1.79	20	0.4	507	693
Raspberry Creek (at water supply res.)	1.26	14	0.3	299	419
Raspberry Creek (at mouth)	3.15	35	0.8	888	1,210
Smith Creek (at mouth)	3.47	39	1.0	983	1,340
Tunnel Creek (at water supply res.)	5.39	60	1.8	1,295	1,790
Tunnel Creek (at tailings dam)	9.96	112	3.9	2,372	3,280
Tunnel Creek (at mouth)	11.07	124	4.4	2,716	3,740
White Creek (at mouth)	2.98	33	0.8	753	1,040
Wilson River (at wells)	116.00	1322	104	16,900	23,600
Wilson River (at mouth)	189.90	1334	197	26,300	36,800

1/ Based on 11.4 cfs/mi^2 for Keta, Blossom, and Wilson rivers, and 11.2 cfs/mi^2 for all other streams.

2/ Calculated according to Forest Service (1980a) methodology (see Appendix D). Numbers rounded to a maximum of three significant digits.

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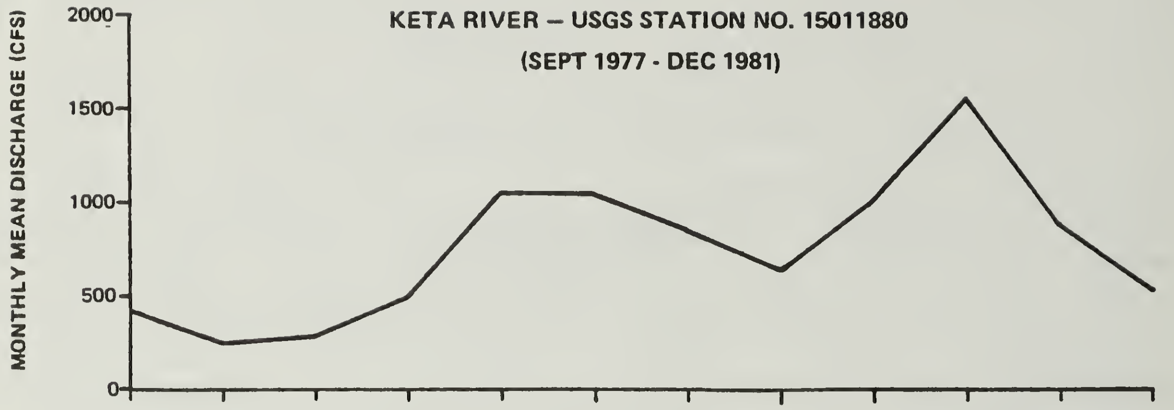
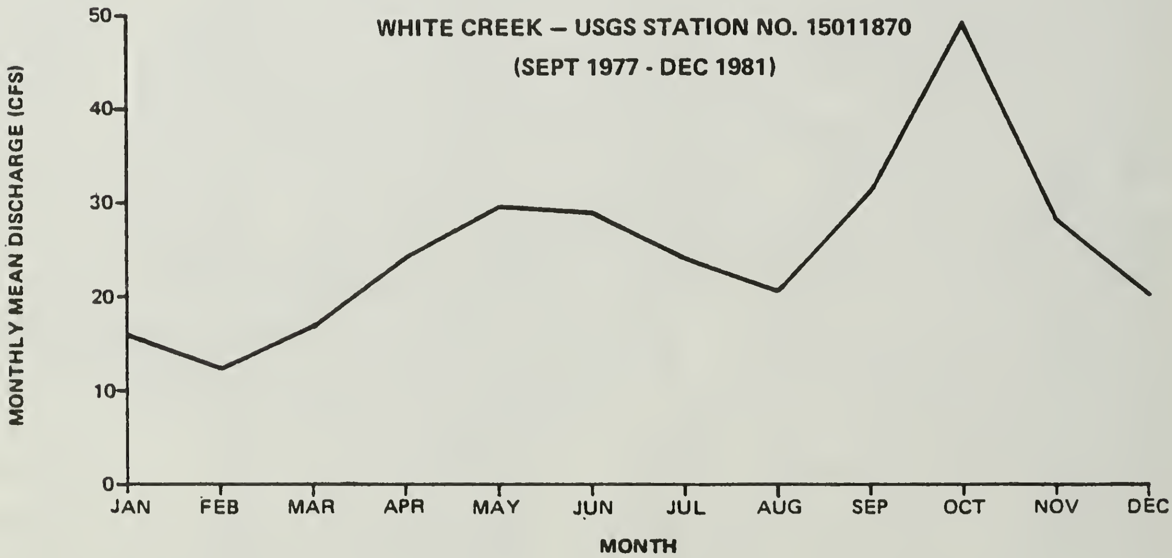




U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-4
SEASONAL STREAMFLOW PATTERNS OF KETA RIVER AND WHITE CREEK	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE VTN 1983f DATE JUN 83	

approximations. The lowest recorded streamflows in the Keta and Blossom rivers and White Creek occurred in late February and early March (USGS 1983). The discharges recorded were 2.0 cfs (0.67 cfs/mi^2) for White Creek, 41 cfs (0.52 cfs/mi^2) for the Keta River, and 52 cfs (0.81 cfs/mi^2) for the Blossom River (USGS 1983, pp. 15, 22, 26).

Streamflow records are also too short to perform statistical analyses for peak flow events (Lindsley et al. 1975, p. 340). Peak flow estimates for project area watersheds were calculated using regional regression equations developed by the Forest Service (1980a, Appendix A) and the results obtained from these equations are presented in Table 3-3. Peak discharges recorded between September 1981 and October 1982 are listed in Table 3-4 for the major project area streams.

Stream basins in the project area exhibit a rapid response to runoff due to the shallow soils, steep topography, and high drainage density. Storm hydrographs of the tributary streams generally have steep rising and falling curves, with peaks of short duration. The Blossom and Keta rivers, because of their larger drainage areas, have longer response times and longer peak durations than the small tributary creeks.

Water rights have been granted to U.S. Borax at three locations in the project area. These water rights, the only ones issued within Misty Fiords National Monument, were filed for and issued in 1978 with the approval of the Forest Service and the Alaska Department of Natural Resources. Two of the water rights were granted on two small unnamed creeks on the northwest side of upper Boca de Quadra for the proposed tailings tunnel construction camp. The other existing water right is for the bulk sampling program and involves both mining and domestic uses. This permit allows a maximum diversion of 2 cfs from White Creek and its tributary, Twenty Dollar Creek (VTN 1983e, p. 21).

Additional existing water uses of the project waters are fish and wildlife habitat (see Section 3.2) and recreation (see Section 3.3.3). No new water uses are known to be planned for the project area.

3.1.4 Groundwater Hydrology

Hydrogeologic Units

Groundwater occurs within three major hydrogeologic units: a soil zone, consisting primarily of muskeg; glacial and alluvial deposits of silt, sand, and gravel; and fractured bedrock (Rowe 1983a, p. 1).

Soil Zone:

The soil zone consists of two major units: residual soils consisting of weathered bedrock, till, and organic debris; and muskegs composed of sphagnum peat, sedge peat, and muck. The residual soils do not

TABLE 3-4

MAXIMUM INSTANTANEOUS DISCHARGES
SEPTEMBER 1981-OCTOBER 1982

Station Location	Maximum Instantaneous Discharge (cfs)	Date	Discharge Per Unit Area (cfs/mi^2)
Beaver Creek (BV-QC-1890)	275	11/05/81	144
Blossom River (BL-QC-1894)	12,000	10/09/82	188
Hill Creek (HC-QC-1875)	4,600	10/09/82	322
Keta River (KE-QC-1880)	13,800	9/08/81	186
Raspberry Creek (RS-QC-19)	466	11/05/81	350
Tunnel Creek (TC-QC-11)	1,610	10/09/82	281
White Creek (WC-QC-1870)	647	11/05/81	240

SOURCE: VTN (1983f, p. 18).

constitute a significant groundwater unit (Rowe 1983a, p. 2). The muskegs occur primarily on gentle slopes and in stream valleys, and are saturated with water throughout the year. Muskegs may range up to 40 ft in thickness, but are generally less than 12 ft thick (Forest Service 1982a, p. 3-5). Muskegs underlain by glacial till may form perched groundwater zones, which are not in direct hydraulic communication with underlying groundwater zones, or they may act as partial hydraulic confining layers for underlying zones (Rowe 1983a, p. 2).

Hydraulic conductivity and specific yield of muskeg deposits have not been measured in the project area. Hydraulic conductivity is believed to be relatively low, based on observations of small surface water ponds formed on muskeg deposits in areas of gentle topography (Golder Associates 1983a, p. 7).

Glacial and Alluvial Deposits:

Glacial drift occurs in scattered deposits over the area, primarily in the lee of major uplands and along the margins of major valleys (Rowe 1983a, p. 2). Alluvial deposits occur along stream courses. In the smaller drainages (e.g., White Creek or Tunnel Creek), alluvial deposits consist of cobbles, gravel, and sand, with few fine sediments (Rowe 1983a, p. 2). Finer sediments may be present in the valleys of larger streams (Rowe 1983a, p. 3).

The hydraulic conductivity of these deposits is greater than about 10^{-3} cm/sec, the effective maximum that can be measured by the packer test techniques utilized (Rowe 1983a, pp. 2, 3). The estimated range of hydraulic conductivity values for the glacial and alluvial materials, based on general published data, is about 10^{-2} to 10 cm/sec (Golder Associates 1983a, p. 7; Rowe 1983a, p. 3). Values may be lower in areas where finer sediments are deposited, such as in the valleys of major streams (Rowe 1983a, p. 3). The specific yield of glacial and alluvial deposits in the project area has not been measured. The estimated porosity of glacial and alluvial materials, based on published data for similar materials from other areas, is in the range of 20 to 40 percent (Golder Associates 1983a, p. 7; Rowe 1983a, p. 3).

Bedrock:

Groundwater occurs within fractures in the metamorphic and igneous bedrock, which underlies the entire project area. The hydraulic conductivity of bedrock has been measured at several facility locations and near the Bear Meadow and Quartz Hill adits (Golder Associates 1983a, p. 8; Rowe 1983a, p. 3). The measured hydraulic conductivity of fractured intrusive rock in the area is quite variable, extending over almost four orders of magnitude, but has a geometric mean of about 5×10^{-6} cm/sec (Golder Associates 1983a, p. 8; Rowe 1983a, p. 4). The estimated large-scale hydraulic conductivity determined from adit

discharge and piezometric level data for the Bear Meadow area was also about 5 x 10^{-6} cm/sec (Golder Associates 1983a, p. 8, 1983b, p. 18; Rowe 1983a, p. 4). This is at the lower end of the range of hydraulic conductivities of "poor aquifers," as classified by DeWiest (1965, p. 171). Tests have been conducted to depths of about 1,000 ft in fractured igneous rock. There is apparently no general relationship between depth and hydraulic conductivity in this depth range (Golder Associates 1983a, p. 9, 1983b, p. 10, Tables 3-1, 3-2; Rowe 1983a, p. 4). Only borehole 80-139 exhibited a general decline in hydraulic conductivity with depth (Golder Associates 1983b, p. 10).

Fractured metamorphic rocks that have been tested at four locations to depths of 200 ft exhibit much less variation in hydraulic conductivity (only about two orders of magnitude), and a higher geometric mean value (about 5 x 10^{-5} cm/sec), than fractured igneous rocks (Golder Associates 1983, p. 9, Figure 8; Rowe 1983a, p. 4).

The bedrock in the Quartz Hill and Bear Meadow areas is moderately well fractured, with fractures spaced from 2 in. to 4 ft apart. Discrete fault and shear zones are occasionally encountered, some of which are well cemented with calcite and zeolites (Golder Associates 1983a, pp. 8-9; Rowe 1983a, p. 4). No specific testing of major fault zones or other structural features has been conducted (Rowe 1983a, p. 5; Rowe 1983b).

Porosity of fractured bedrock in the area is relatively low. The porosity due to existence of fractures in the rock has been estimated to be less than 0.01, based on literature data (Golder Associates 1983a, p. 9, 1983b, p. 11; Rowe 1983a, p. 5).

Groundwater Recharge and Discharge

Recharge to groundwater systems in the project area results from the infiltration of rain and snowmelt. The estimated average recharge to groundwater is about 1 ft per year (Golder Associates 1983a, p. 10, 1983b, p. 14, 18; Rowe 1983a, p. 5). Muskeg may retard the recharge to underlying units, resulting in a slow but steady rate of recharge. In areas where bedrock is exposed, slopes are generally steep, resulting in greater runoff and less recharge to groundwater than in flatter areas (Golder Associates 1983a, p. 10; Rowe 1983a, p. 6).

Discharge of groundwater occurs principally along stream valleys or other areas of low elevation. Seeps and springs are reportedly common in the mine area along the flanks of Quartz Hill and in areas of lower elevation (Rowe 1983a, pp. 11-12).

Local Groundwater Conditions - Mine Area

Formation Properties:

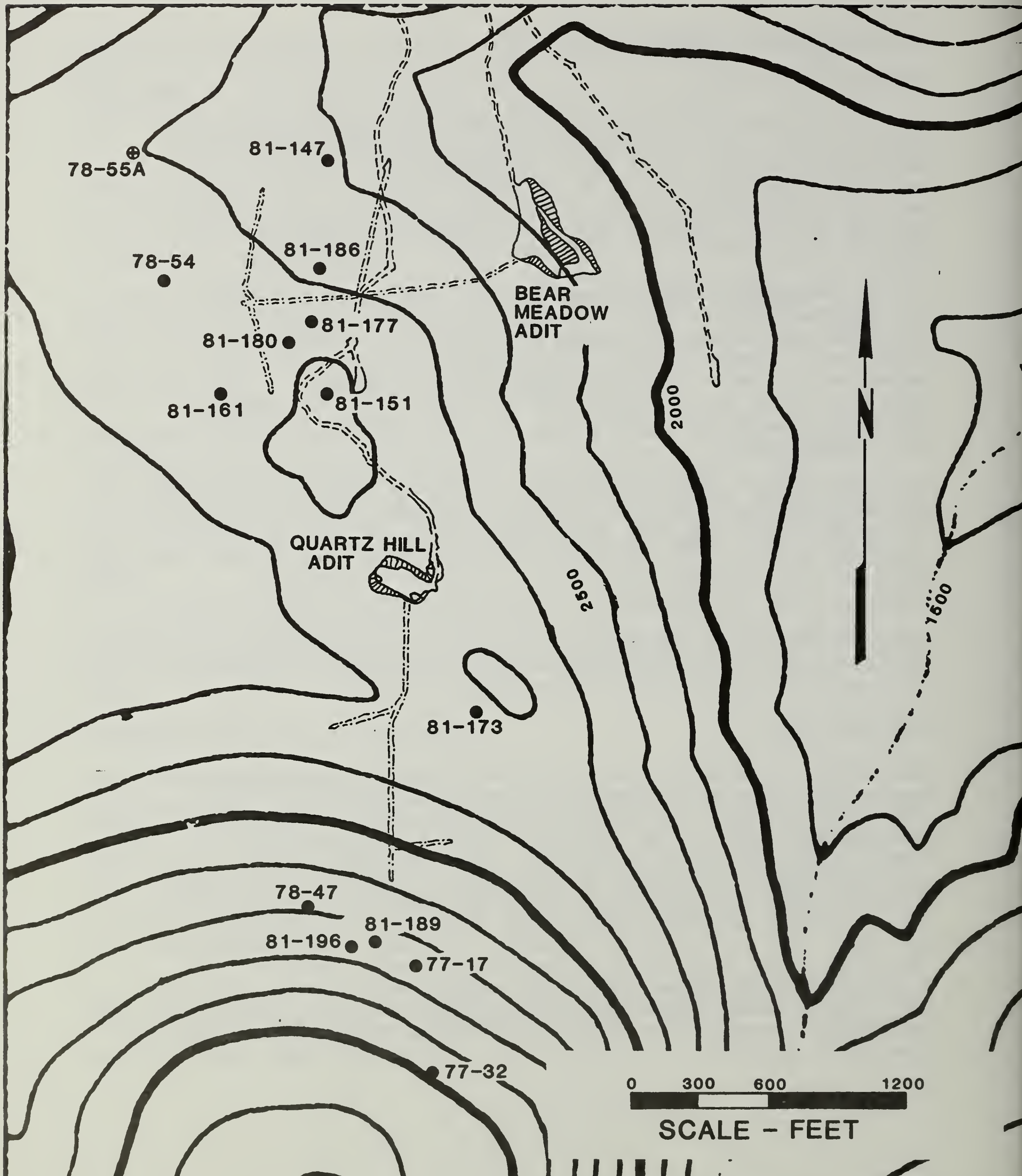
Tests for hydraulic conductivity were conducted at three boreholes in the Bear Meadow area (81-177, 81-180, and 81-186, Figure 3-5) and two boreholes in the Quartz Hill area (81-189 and 81-196, Figure 3-5) during the summer of 1981, and at one deeper borehole in each of the two areas in the summer of 1983 (77-10 and 80-139, Figure 3-6). For the 1981 data, the geometric mean value of hydraulic conductivity in the Bear Meadow area is 8.1×10^{-6} cm/sec, with a range of about 10^{-7} to 10^{-4} cm/sec (Golder Associates 1983a, p. 14; Rowe 1983a, p. 10). A comparable value of about 5×10^{-6} cm/sec was determined from piezometric level and adit discharge data at the Bear Meadow adit. For the 1981 data, the geometric mean value of hydraulic conductivity in the two holes in the Quartz Hill area is 4.0×10^{-6} cm/sec, with a range of about 10^{-7} to 10^{-4} cm/sec (Golder Associates 1983a, pp. 14-15; Rowe 1983a, p. 11). The 1983 test data (Golder Associates 1983b, Tables 3-1, 3-2) are generally consistent with the 1981 data.

Specific yield of the rock mass in the vicinity of the Bear Meadow adit has been estimated to be 0.003, based on measurements of water levels in open drill holes recorded during excavation of the adit (Golder Associates 1983b, p. 11). A second estimate of 0.0002 for the specific yield was calculated from the effect of distributed groundwater recharge on the adit discharge rate (Golder Associates 1983b, p. 12).

A specific storage of approximately 10^{-8} ft^{-1} has been estimated from variations in head data measured in borehole 81-161 (Figure 3-5) in response to adit discharge (Golder Associates 1983b, p. 13).

Adit Discharges:

Discharge from the Bear Meadow and Quartz Hill adits has been monitored continuously since August 1981. Adit locations are shown on Figure 3-5. Discharges have averaged about 45 gpm from the Bear Meadow adit and about 25 to 40 gpm from the Quartz Hill adit during periods of no mining (Golder Associates 1983a, p. 13, 1983b, pp. 7-8). These discharges appear to exhibit a moderate seasonal variation, with higher discharge rates corresponding to the spring snowmelt and autumn rainy seasons (Golder Associates 1983a, p. 13, 1983b, p. 8; Rowe 1983a, pp. 9-10). The adit discharge rates were relatively high in August and September of 1981, when mining of the adits was begun, and in July of 1983 when bulk sampling was conducted. Maximum discharges have been 200 gpm from the Bear Meadow adit (Golder Associates 1983b, Figure 3-2) and 165 gpm from the Quartz Hill adit (Golder Associates 1983a, p. 13; Rowe 1983a, pp. 9-10).



LEGEND

⊕ EXISTING PIEZOMETERS
(Installed 1981)

● DEEP PIEZOMETERS
(Installed 1983)

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LOCATION OF
PNEUMATIC PIEZOMETERS

SOURCE GOLDER ASSO. (1982a) DATE NOV 83

FIGURE
3-5

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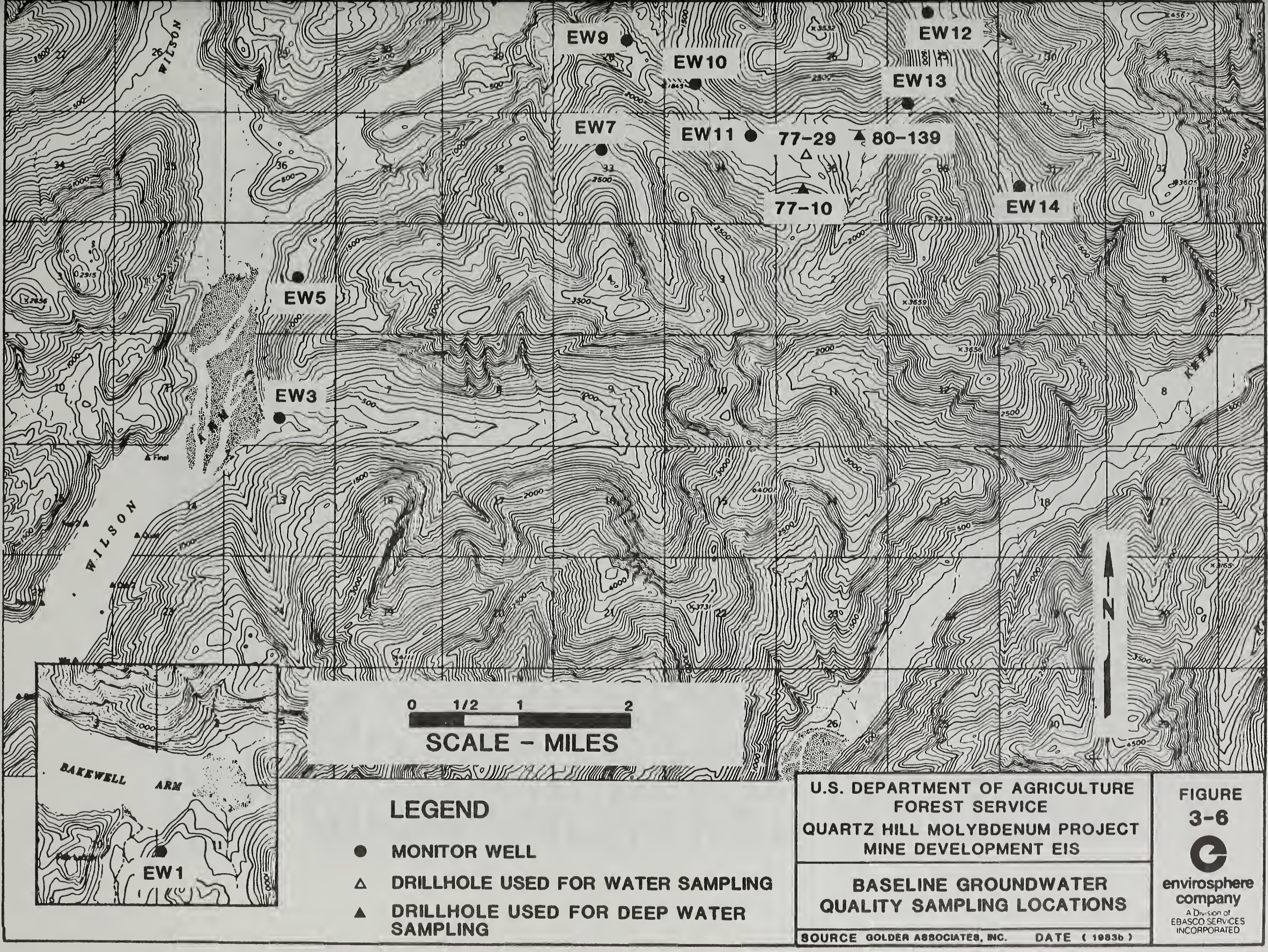

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BASELINE GROUNDWATER QUALITY SAMPLING LOCATIONS

SOURCE GOLDER ASSOCIATES, INC. DATE (1983b)

FIGURE 3-6

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Groundwater Levels:

Water levels in open boreholes reflect the average piezometric head over the entire open interval of the hole. In general, these water levels correspond to local topographic variations, with water level highs in the Quartz Hill area and the southern flank of North Ridge, and water level lows along White Creek and Beaver Creek (Golder Associates 1983a, Figure 4, 1983b, Figure 3-1; Rowe 1983a, Figure 2). Differences in water level elevations between 1979 and 1982 (Golder Associates 1983a, Figure 5; Rowe 1983a, Figure 3) indicate that water level declines of more than 100 ft have occurred in the immediate vicinities of the Quartz Hill and Bear Meadow adits. However, water level declines in excess of 10 ft have generally been confined to within about 2,000 ft of the adits (Golder Associates 1983a, Figure 5; Rowe 1983a, Figure 3). At many piezometers, water levels dropped rapidly during the autumn of 1981 (Golder Associates 1983a, Appendix A), presumably in response to mining of the adits.

Water level data also indicate that gradients are generally downward in both the Quartz Hill and Bear Meadow areas, suggesting regions of groundwater recharge (Golder Associates 1983a, p. 11; Rowe 1983a, p. 8). Some upward gradients exist on the flanks of Quartz Hill, where several boreholes flowed at the surface before the Quartz Hill adit was constructed. The pneumatic piezometer data also indicate that seasonal fluctuations in water level elevations are more pronounced near the top of Quartz Hill than in Bear Meadow. Highest water levels occur during periods of snowmelt and periods of heavy rainfall, suggesting rapid response of water levels to local recharge (Golder Associates 1983a, pp. 12-13; Rowe 1983a, p. 9). Piezometers located very near the adits show relatively little seasonal fluctuation, suggesting that a condition of essentially steady drainage into the adits has developed (Golder Associates 1983a, p. 12; Rowe 1983a, p. 9).

Groundwater Movement:

Based on available water level data, groundwater movement within the bedrock in the mine area appears to generally follow the local topography. Water appears to move from areas of higher elevation (Quartz Hill, North Ridge) to areas of lower elevation (White Creek, Beaver Creek). The Bear Meadow area, intermediate in elevation, appears to generally be a recharge area. Major discharge in the area appears to occur along White Creek, with lesser discharge to springs, tributary streams, and Beaver Creek.

Piezometric and hydraulic conductivity data indicate that groundwater flow occurs at depths in excess of 500 ft in the mine area (Golder Associates 1983a, p. 16; Rowe 1983a, p. 12). There is no evidence to suggest that geologic structure or major fault zones exert any significant control on groundwater movement in the mine area. Water level maps for the area (Golder Associates 1983a, Figure 4, 1983b,

Figure 3-1; Rowe 1983a, Figure 2) do not indicate any perturbations that could be attributed to the Stephens Fault, or any other structural feature, acting as either a barrier to or conduit for groundwater flow. During an inspection of the Bear Meadow adit in August 1983, it was noted that significant water-bearing fractures were rare. Where the Stephens Fault and other fault zones are intersected in the workings, the degree of wetness of the fault zones appeared similar to that of adjacent unsheared rock (Golder Associates 1983b, Appendix E). However, no direct hydraulic testing has been conducted on any fault zones or other structural features in the area, and the possibility remains that such features could exhibit significantly different hydrologic properties (either higher or lower) than the adjacent rock masses.

The locations of springs and seeps in the mine area have not been mapped. Springs and seeps are reportedly common throughout the area along the flanks of Quartz Hill and in areas of lower elevation (Rowe 1983a, pp. 11, 12).

Local Groundwater Conditions - Other Areas

Formation Properties:

Tests have been conducted or attempted at most of the relatively shallow (25 to 50 ft deep) environmental monitoring wells drilled in the area (Figure 3-6). Three of the wells, EW-10 and EW-11 in the Beaver Creek valley and EW-14 in the Hill Creek valley, were completed in glacial or alluvial deposits. The hydraulic conductivity of those deposits was too high to be tested by the methods utilized, and thus is greater than about 10^{-3} cm/sec.

Wells were completed into igneous bedrock at three locations: wells EW-5 in the Wilson Arm area, EW-12 in the upper Hill Creek area, and EW-13 in the lower White Creek area. Measured hydraulic conductivities ranged from 10^{-5} to 5×10^{-4} cm/sec (Golder Associates 1983a, Table 3; Rowe 1983a, pp. 13, 16), one to two orders of magnitude greater than that of the igneous bedrock tested at the mine area. This may reflect greater weathering at shallow depths, or more intensive fracturing of shallow bedrock along the streams (Golder Associates 1983a, pp. 17-18; Rowe 1983a, p. 13).

The other three monitoring wells, EW-1 in the Bakewell Arm area, EW-3 in lower Tunnel Creek Valley, and EW-9 on Bruce's Nose adjacent to the lower Beaver Creek, were completed into gneiss or other metamorphic rocks. Measured hydraulic conductivity of these rocks ranged from 10^{-5} to 4×10^{-4} cm/sec, typical of metamorphic rocks in the area.

No aquifer testing has been performed in the Aronitz Creek valley, and no testing of storativity or measurement of porosity has been conducted at any site other than the mine area.

Groundwater Movement:

Water levels measured in well EW-13 in the lower White Creek valley are slightly above land surface, indicating an area of groundwater discharge. Relatively high total dissolved solids in well EW-13 have also been interpreted as indicating an area of groundwater discharge (Golder Associates 1983a, p. 18; Rowe 1983a, pp. 13-14). Water levels in the other environmental monitoring wells ranged from 2 ft below land surface in EW-3 and EW-11, to 19 ft below land surface in EW-5 (Golder Associates 1983a, pp. 19-21; Rowe 1983a, pp. 14-16). These water level data are not sufficient to determine local groundwater flow rates or directions. Based on their topographic positions, the valleys proposed as locations of most of the project facilities would be expected to be groundwater discharge areas. Groundwater flow in alluvial deposits is probably parallel to the streams, in downstream directions.

Wilson River Well Field Alternative:

The location of the Wilson River well field alternative is shown on Figures III-1 through III-5, Appendix A. The location is in the area 0.5 to 1.5 mi upstream from the confluence of the Wilson and Blossom rivers. In 1982, an area downstream of the confluence with the Blossom was investigated by geologic mapping, shallow drilling, and water level and water quality monitoring. Data from three 75-ft deep observation wells indicated that the groundwater was too brackish for project use, but that tidal fluctuations in the fjord are reflected in groundwater level variations, suggesting good hydraulic connection between groundwater and surface water in the area (Bechtel undated, unpaginated).

During the 1983 field season, four additional observation wells were constructed in the well field area, and a seismic-refraction survey was conducted. These investigations indicated alluvial deposits at least 275 ft thick and about 1,400 ft wide along a reach of the river more than a mile long (Bechtel undated, unpaginated). Based on the classification of materials reported on borehole logs, two major water-bearing zones may be encountered (Welton 1984):

- A sand and gravel zone from 10 to 20 ft in depth, with an assumed hydraulic conductivity of 2×10^{-2} cm/sec, and

- A fine sand zone from 40 to 90 ft in depth with an assumed hydraulic conductivity of 1×10^{-2} cm/sec. The assumed hydraulic conductivities were inferred from borehole log material classifications (Welton 1984). No aquifer testing has yet been conducted.

Based on a resistivity survey conducted in the Wilson River valley in 1983, the saltwater/freshwater interface in the subsurface is expected to be downstream of the confluence of the Wilson and Blossom rivers

(Bechtel undated, unpaginated), at least 1,000 ft downstream from the downstream end of the well field alternative (Welton 1984).

3.1.5 Water Quality

Surface Water Quality

Surface water quality in the project area has been measured since late 1976 by U.S. Borax (VTN 1978, 1979, 1980a, 1981a, 1982b, 1983f), the U.S. Geological Survey (USGS), the Alaska Department of Environmental Conservation (ADEC), and the University of Alaska (Burrell 1983). Although sampling has taken place on most of the tributaries and at more than one location on the Blossom, Wilson, and Keta rivers (Figure 3-3), only the data from those stations with a substantial record for adequate statistical analysis were used for this characterization. The data from the other stations were compared with the existing characterization in order to identify any inconsistencies and substantiate spatial and seasonal variations. The following discussion of water quality parameters is applicable to all of the creeks and rivers in the project area, except where specific differences for a given stream are noted. Table 3-5 presents the existing water quality characterizations by station that are used to evaluate project impacts.

Four types of analyses were performed on the entire water quality data base (VTN 1983f). In order to determine temporal or seasonal trends, monthly means were calculated for the key parameters. Comparisons were made among streams in different drainage basins to spot spatial trends. A series of statistical regression analyses were run to evaluate possible relationships between flow and total dissolved solids (TDS), major ions, or trace metals. Finally, several parameters from wells and the adjacent streams were compared to find evidence of groundwater input. Major factors influencing surface water quality in the project area are the short residence time between rainfall and runoff, and the flushing of stored water from muskegs. This situation, coupled with the large volume of precipitation, results in extremely diluted streams for which major temporal or spatial trends or flow relationships cannot be discerned within the detection limits of the present data base. The consistently higher TDS values in the White Creek samples could indicate that highly mineralized groundwater is contributing to the base flow. Groundwater inflow was not discernible in the other project area streams.

Because the streams in the project area have not been assigned a specific use classification by ADEC, the streams are subject to the strictest standards associated with all of the use classes (18 AAC 70.030; ADEC 1982). The water quality standards that will apply are presented in Appendix E. The existing surface water quality meets the ADEC standards except for pH and temperature limits. All of the creeks and rivers in the project area have naturally occurring pH values below

TABLE 3-5

EXISTING WATER QUALITY CHARACTERIZATION[1/]

Parameter[2,3/]	Beaver Creek BV-QC-1890			Blossom River BL-QC-1894			White Creek WC-QC-1870			Upper Hill Creek HC-QC-1865		
	min.	max.	mean	min.	max.	mean	min.	max.	mean	min.	max.	mean
Temperature, °C	0.0	16.5	5.6	0.0	13.9	5.2	0.0	11.9	4.5	0.0	10.2	4.8
Dissolved Oxygen	8.0	16.0	11.7	9.2	13.6	11.8	8.7	16.0	11.8	10.0	14.0	11.9
pH, units	5.2	7.1	6.1	5.5	7.1	6.1	4.9	7.5	6.2	5.4	7.3	6.1
Color, pcu	<2	30	8.4	<1	15	6.3	<2	15	2	<2	25	7.4
Turbidity, NTU	0.2	17.0	6.1	0.1	13.0	2.5	0.1	15.0	4.4	0.3	35	8.4
Conductivity, µmhos/cm	14	60	29.5	7	32	19.7	7	138	52	3	90	14.9
Total Dissolved Solids	12	52	22.0	10	29	19.2	7	98	35	5	29	11.9
Suspended Solids	<1.0	48	5.2	<1	<1	-	<1.0	3	1	<1.0	2	1.0
Total Hardness (as $CaCO_3$)	5	15	9.7	7	17	11.3	4	61	19	4	13	6.3
Alkalinity	2	60	11.4	5	13	8.7	1	20	6	2	69	11.3
Oil and Grease	<0.1	1.1	0.3	<0.1	1.80	0.7	<0.1	1.3	0.3	<0.1	5	0.8
Total Organic Carbon	1.3	5.5	2.5	2.4	18.0	7.9	1.2	14.0	3.7	1.0	4.5	2.4
Ammonia+Organic Nitrogen (as N)	<0.1	1.4	0.4	<0.1	0.8	0.4	<0.1	4.5	0.5	<0.1	3.3	0.5
Nitrate Nitrogen (as N)	<0.05	0.22	0.06	<0.05	0.13	0.09	<0.05	0.12	0.05	<0.05	0.42	0.13
Total Phosphorus (as P)	<0.05	0.75	0.08	<0.05	0.06	0.03	<0.05	1.30	0.07	<0.05	1.18	0.10
Silica (as SiO_2)	2.2	5.0	3.4	1.2	5.0	3.1	2.5	7.2	4.8	0.8	4.3	2.6
Sulfate (as SO_4)	<1.0	13.0	6.5	<1.0	6.0	3.5	<1.0	53	16	<1.0	7.2	2.8
Chloride	<1.0	2.9	1.0	<1.0	1.2	0.9	<1.0	2.6	0.9	<1.0	4.0	1.0
Calcium	1.6	5.4	3.5	2.4	6.1	4.0	1.2	23.0	7.2	1.2	4.7	2.2
Arsenic	<0.005	0.006	<0.005	<0.005	<0.005	-	<0.005	0.016	<0.005	<0.005	0.016	<0.005
Cadmium	<0.002	<0.002	-	<0.002	0.003	<0.002	<0.002	<0.002	-	<0.002	0.003	<0.002
Copper	<0.003	<0.003	-	<0.003	<0.003	-	<0.003	0.005	<0.003	<0.003	0.006	<0.003
Iron	<0.005	0.270	0.145	0.010	0.160	0.079	0.020	0.100	0.045	<0.005	0.310	0.055
Lead	<0.010	<0.010	-	<0.010	<0.010	-	<0.010	<0.010	-	<0.010	<0.010	-
Manganese	0.003	0.023	0.009	<0.002	0.014	0.009	0.002	0.018	0.009	<0.002	0.020	0.007
Molybdenum	<0.020	<0.020	-	<0.020	<0.020	-	<0.020	0.060	<0.020	<0.020	0.050	<0.020
Zinc	<0.002	0.040	0.009	<0.002	0.036	0.014	<0.002	0.130	0.015	<0.002	0.040	0.008

1/ Source: VTN (1983f), Appendix A. (Sampling period September 1976 through December 1982.)
2/ All units mg/l as element unless otherwise noted.
3/ All trace metals are dissolved portion only. The difference in dissolved and total recoverable values is minimal, due to the very low concentration of suspended solids.

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TABLE 3-5 (Continued)

Parameter	Upper Keta River KE-QC-1860			Tunnel Creek TC-QC-11			Lower Hill Creek HC-QC-1875			Lower Keta River KE-QC-1880		
	min.	max.	mean	min.	max.	mean	min.	max.	mean	min.	max.	mean
Temperature, °C	0.0	11.5	5.6	1.8	9.5	6.4	0.0	12.0	5.0	0.0	11.0	4.8
Dissolved Oxygen	4.9	19.5	11.6	9.4	16.0	11.4	10.2	17.0	12.5	9.0	16.0	12.0
pH, units	5.5	7.9	6.3	5.1	6.9	6.1	5.6	7.6	6.3	5.2	7.3	6.2
Color, pcu	<1	15	5.3	<2	10	6	<1	25	6.1	<1	20	7.4
Turbidity, NTU	0.4	17.0	6.5	0.2	15.0	8.0	0.0	22.0	5.95	0.1	14.0	4.3
Conductivity, μhmos	3	48	25.6	6	52	20.8	9	58	21.3	6	37	15.8
Total Dissolved Solids	10	53	19.6	2	30	13.8	5	53	20.2	5	39	15.5
Suspended Solids	<1	4	1.3	<1	3	1.2	<1	2	1.1	<1	2	1.1
Total Hardness (as $CaCO_3$)	6	11	8.2	2	9	5.8	4	18	10.4	4	12	7.8
Alkalinity	3	52	12.4	8	34	14.8	4	52	10.9	3	20	8.5
Oil and Grease	<0.1	<5.00	-	<0.1	<5.00	-	<0.1	<5.00	-	<0.1	1.4	0.3
Total Organic Carbon	1.0	8.6	2.8	1.3	6.7	3.0	1.0	12.2	3.7	1.2	9.0	4.0
Ammonia+Organic Nitrogen (as N)	<0.1	2.2	0.4	<0.1	1.7	0.5	<0.1	5.3	0.6	<0.1	2.2	0.4
Nitrate Nitrogen (as N)	<0.05	0.90	0.16	<0.05	0.70	0.15	<0.05	0.4	0.11	<0.05	0.44	0.13
Total Phosphorus (as P)	<0.05	1.10	0.10	<0.05	2.15	0.19	<0.05	1.18	0.09	<0.05	1.18	0.07
Silica (as SiO_2)	0.3	4.8	2.8	0.3	3.5	2.3	1.8	5.2	3.4	1.1	4.3	2.7
Sulfate (as SO_4)	<1.0	10	3.2	<1.0	6.0	2.2	<1.0	12	5.3	<1.0	7.3	2.9
Chloride	<1.0	2.0	1.0	<1.0	1.7	1.01	<1.0	2.9	1.01	0.20	5.0	1.05
Calcium	0.1	4.0	2.8	0.1	3.2	2.0	1.4	6.7	3.7	1.0	4.3	2.7
Arsenic	<0.005	0.030	<0.005	<0.005	0.010	0.006	<0.005	0.008	<0.005	<0.005	0.006	<0.005
Cadmium	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	0.004	<0.002
Copper	<0.003	0.009	<0.003	<0.003	0.006	<0.003	<0.003	0.006	<0.003	<0.003	0.011	<0.003
Iron	<0.005	0.460	0.068	<0.005	0.180	0.041	<0.005	0.280	0.051	0.020	0.140	0.067
Lead	<0.010	<0.010	-	<0.010	<0.010	-	<0.010	<0.010	-	<0.010	0.020	<0.010
Manganese	<0.002	0.010	0.005	<0.002	0.036	0.005	<0.002	0.010	0.006	<0.002	0.016	0.007
Molybdenum	<0.020	<0.020	-	<0.020	<0.020	-	<0.020	<0.020	-	<0.020	<0.020	-
Zinc	<0.002	0.015	0.006	<0.002	0.040	0.012	<0.002	0.080	0.012	<0.002	0.090	0.018

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the minimum standard of 6.5, and Wilson River and Beaver Creek have summer temperatures that surpass the 15°C maximum.

In general, the waters can be characterized as being slightly acidic, very soft, poorly buffered, and contain very low levels of dissolved and suspended solids, nutrients, organics, and trace materials.

Water temperatures range from an average minimum of 0°C during the winter period of November through March to an average maximum of 12°C during the summer period of July through September. During most of the year, variations in temperature are minimal, but in the summer months fluctuations of ± 3°C, probably due to rapid changes in weather and corresponding snowmelt, have been recorded.

The dissolved oxygen (DO) concentration is usually above 90 percent saturation, except at the end of the summer when saturations around 80 percent have been measured. This seasonal drop in DO corresponds with the decomposition of fish during the salmon run and is especially noticeable in the Keta River data. All of the streams also have measurements of over 100 percent saturation during high flow periods in May and October.

Sedimentation patterns are controlled by basin geology, slope, vegetation, and hydrology. Despite the steep slopes in the area, little suspended sediment originates from the densely vegetated valley sides and organic muskeg deposits (VTN 1979, p. 5-51). The Blossom and Keta rivers, with headwater snow fields of 0.2 and 0.03 sq mi, respectively, receive a relatively small proportion of their total sediment load from glacial-like activity of the snowfields. The majority of suspended solids and bedload material most likely originates from streambank erosion during high flow events, reworking of glacial deposits in the valley floor, and natural landslides depositing material into the streambed.

Stream sediment loads consist of suspended sediment and bedload, a dynamic process that varies with changing stream discharge and sediment size. Studies have shown that at any given time, the bedload of a stream generally represents 5 to 12 percent of the total sediment load (Vanoni 1975; U.S. Department of Transportation 1975). Data collected to date indicate that natural levels of suspended solids are very low (0 to 23 mg/l) for streamflow levels at or below the average annual flow (VTN 1983f, Appendix A-2). Maximum suspended solids concentrations measured were over 560 mg/l in the Keta River, over 200 mg/l in White Creek and the Blossom River, and less than 40 mg/l for all other streams (VTN 1983f, Appendix A-2).

Estimates of average annual ambient sediment loads in the project area have been calculated by the Forest Service (1984) to be approximately 310 tons/mi^2, including bedload. Average annual ambient sediment load for the Keta River has been estimated by VTN to be approximately

31,400 tons/yr at USGS gage 15 0118 80, or the equivalent of 423 tons/mi^2 (VTN 1984, p. 5). The range in sediment load for the major rivers corresponding to these values is presented below. The available data indicate that the majority of the annual sediment load occurs during a few storm periods during the year, with low sediment contributions the remainder of the year (VTN 1984, p. 5).

Ambient Sediment Load Estimates

River	Basin Size (mi^2)	Sediment Load (Tons/Year) (Based on 310 tons/mi^2)	(Based on 423 tons/mi^2)
Keta River	78.2	24,242	33,079
Blossom River	72.9	22,599	30,837
Wilson River	113 1/	35,030	47,799

1/ Only the area downstream of Wilson Lake is used here because it is assumed that Wilson Lake traps nearly all sediment flowing into it from upstream areas.

Most fresh waters have pH values ranging from about 5.5 to slightly over 8.0 (Hem 1975, p. 93). The ranges of pH values in the project area varied considerably, depending on the type of terrain being drained (bare rock or muskeg), but most streams exhibit slightly acidic water. The overall mean is 6.2, with a minimum of 4.9 and a maximum of 7.9 measured at the White Creek and Keta River stations, respectively.

In general, the surface waters in the project area have low TDS concentrations and are a calcium-bicarbonate-sulfate type water, with the bicarbonate ion as the dominant anion, except in the White and Beaver creek drainages where the sulfate anion dominates due to the predominance of sulfur-containing rock formations. The low alkalinity values indicate that these streams have a very low buffering capacity. The low levels of total hardness, predominantly noncarbonate hardness due to magnesium in most samples, place these streams in the "very soft" category.

All the streams in the project area exhibit extremely low dissolved nutrient concentrations, usually around the lower levels of detection. Because of the high precipitation, both the soils and muskegs have become extremely deficient in nutrients. The higher recorded nutrient values correspond with the decomposition of salmon carcasses (Burrell

1983, Appendix 5, p. 14). The concentrations of trace heavy metals consistently detected (iron, manganese, and zinc) were usually very low. The analytical methods used were not sufficiently sensitive to detect the very low levels of arsenic, cadmium, copper, and mercury that could affect freshwater aquatic organisms (EPA 1980b, 1980c, 1980d, 1980e).

Groundwater Quality

Groundwater quality within the project area has been sampled by Golder Associates on six occasions since October 1981 at 10 environmental wells and two drillholes (Hole 77-10 was sampled at two depths). Deep groundwater samples were obtained from two boreholes at various depths during 1983. The locations of these holes are shown in Figure 3-6 and the data are presented in Appendix E, Tables V-1 and V-2. Additional groundwater quality samples have been taken by the U.S. Geological Survey, Alaska Department of Environmental Conservation, and U.S. Borax.

The quality of groundwater sampled from wells completed in the igneous intrusive bedrock, metamorphic bedrock, and glacial and alluvial deposits is summarized in Table 3-6. It is uncertain whether differences in water quality are characteristic of the rock types or a function of sample location within the groundwater flow regime (Golder Associates 1983b, p. 22). Comparison of the results of the chemical analyses of groundwater samples with primary and secondary drinking water standards (Appendix E) indicates that groundwater quality is generally good. Three parameters that consistently exceed drinking water standards at 12 of the 19 locations are color, iron, and manganese. The mean pH values at EW-1 (Bakewell Lake area), EW-3 (lower Tunnel Creek), and EW-9 (lower Beaver Creek) are below the 6.5 minimum standard probably due to the influence of overlying muskeg. The gross alpha radioactivity standard is exceeded in four locations: EW-13 (White Creek), 77-10 (30 ft and 190 ft) (Bear Meadow core hole), and 77-29 (Bear Meadow adit). In addition, the standards for total dissolved solids and sulfate are exceeded at all five White Creek sample locations (EW-13 and 80-139, all depths). The standard for selenium is exceeded at EW-13 and that for zinc at 77-10 (170-224), the Bear Meadow deep core hole.

Groundwater temperatures varied both spatially and temporally, from 0°C to 12°C. The greatest variation is observed in wells completed in bedrock in areas of relatively localized groundwater flow systems. Dissolved oxygen concentrations were expectedly low. Color measurements of groundwater varied widely, generally higher in the fall, possibly reflecting the leaching of decaying organic matter into the groundwater at that time (Rowe 1983a, p. 24). In general, radioactive constituents are present in relatively minor amounts.

TABLE 3-6

EXISTING GROUNDWATER QUALITY SUMMARY1/

Parameter	Primary Rock Type2/ Igneous	Metamorphic	Glacial Alluvial
Temperature, °C	0.0-11.0	2.0-12.2	4.2-8.5
pH, units (field)	5.7-8.9	5.2-7.4	5.8-7.1
Specific conductance, µmhos/cm	68-1303	46-330	41-430
Total dissolved solids, mg/l	47-1200	45-180	17-360
Sodium, mg/l	0.1-21.0	0.1-6.0	<0.1-17.0
Potassium, mg/l	<0.1-3.6	<0.1-3.6	<0.1-0.5
Calcium, mg/l	6.1-320	5.7-53	4.5-72
Magnesium, mg/l	0.5-6.4	0.5-2.5	0.3-2.3
Bicarbonate alkalinity, mg/l	17-270	17-150	8.0-160
Sulfate, mg/l	6-750	1.0-17	3.5-55
Chloride, mg/l	<1.0-2.0	<1.0-1.0	<1.0-2.0
Fluoride, mg/l	<0.1-3.6	<0.1-0.3	<0.1-1.0
Silica, mg/l	8.0-20	2.3-25	1.6-19
Iron, mg/l	0.01-3.2	0.15-35	0.2-12
Manganese, mg/l	0.051-2.5	0.051-1.0	0.01-1.6
Zinc, mg/l	<0.002-0.31	0.003-0.12	<0.002-0.12
Molybdenum, mg/l	<0.02-0.85	<0.02-0.04	<0.02-0.02
Nitrate, mg/l as N	<0.02-0.52	<0.02-0.75	<0.02-0.87
Total Kjeldahl nitrogen, mg/l as N	<0.1-1.2	<0.01-1.1	0.1-2.0
Ammonia, mg/l as N	<0.1-1.2	<0.01-0.95	<0.1-1.4
Total phosphate, mg/l as P	<0.05-0.45	<0.05-0.16	<0.05-2.20
Dissolved oxygen, mg/l	0.9-7.1	0.1-7.1	1.0-6.6
Total organic carbon, mg/l	0.4-24	0.2-34	1.5-17
Gross alpha, pCi/l	<0.4-57.0	<0.4-5.0	<0.2-3.1
Gross beta, pCi/l	2.0-31.0	<1.0-4.0	<1.0-5.0
Color, units	<2-100	<2-750	5-600

1/ This table is a summary of six sample sets collected at 13 locations (i.e., 78 samples). Samples were collected at each location during October 1981; June, August, and October 1982; and June and October 1983.

2/ Grab sample locations
Igneous: EW-5, EW-12, EW-13, 77-10 (30 ft), 77-10 (190 ft), 77-29
6 locations x 6 sets = 36 samples
Metamorphic: EW-1, EW-3, EW-7, EW-9
4 locations x 6 sets = 24 samples
Glacial/alluvial: EW-10, EW-11, EW-14
3 locations x 6 sets = 18 samples

SOURCE: Golder Associates 1983b, Tables D-15, D-16, and D-17.

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The predominantly calcium bicarbonate type water changes to calcium sulfate type water with age and/or depth (see EIS Appendix E, Table V-2). The waters in EW-1, EW-3, EW-9, EW-10 (middle Beaver Creek), and EW-14 would be categorized as "soft" with hardness values not exceeding 60 mg/l as $CaCO_3$. "Moderately hard" water (60-120 mg/l) is found in EW-7 (Raspberry Creek), EW-11 (upper Beaver Creek), EW-12 (lower Hill Creek), and 77-10 (30 ft and 190 ft). EW-5 (fuel cache), EW-13, 77-29, and all of the deep groundwater locations have "hard" water, ranging from 120 to 900 mg/l as $CaCO_3$. The high concentrations of dissolved solids at EW-5, EW-13, 77-29, and 80-139 are probably indicative of older groundwaters that have become more mineralized through longer contact with the bedrock. TDS concentrations of samples from wells in igneous rocks, metamorphic rocks, or glacial/alluvial sediments, however, did not display any apparent differences that could be attributed to rock type alone. In addition, no significant seasonal variations in TDS have been observed (Rowe 1983a, p. 20).

For most samples the nutrient levels were below their respective lowest level of detection for the analytical method used, so no spatial variations in nutrient levels could be discerned. Concentrations of trace constituents, primarily metals, in the groundwater samples are also close to their respective lowest level of detection. The two main exceptions are iron and manganese. There does not appear to be any correlation between the concentrations of these two metals and rock type, and no consistent temporal variations are evident (Rowe 1983a, p. 21).

3.1.6 Physical Oceanography

The marine environment, interacting with and impacted by the Quartz Hill project, is comprised of Boca de Quadra and Smeaton Bay, both silled fjord systems. The presence of sills physically restricts communication and free exchange of deep basin waters with oceanic waters outside the fjord. The oceanography of the systems is influenced by topographic features, freshwater input, wind and tidal influences, and characteristics of adjacent source waters including Revillagigedo (Revilla) Channel/Dixon Entrance for Boca de Quadra and Behm Canal for Smeaton Bay. Oceanographic monitoring programs have been performed in both fjords by the University of Alaska Institute of Marine Science from October 1978 through December 1983 (Burrell et al. 1980; Burrell 1981, 1982; Nebert et al. 1982; Nebert 1983a, 1984, 1985).

Description of Boca de Quadra and Smeaton Bay Fjords

The Boca de Quadra fjord extends about 60 km from its outermost sill in the Revilla Channel to its head, the mouth of the Keta River. Four smaller arms (Badger Bay/Weasel Cove, Vixon Bay, Mink Bay, and Marten Arm) extend from the middle reach of Boca de Quadra. From the Keta

River seaward are three basins, the inner basin, the central basin, and the outer basin. Figures 3-7 and 3-8 present the Boca de Quadra system and the longitudinal bathymetry of the fjord, respectively.

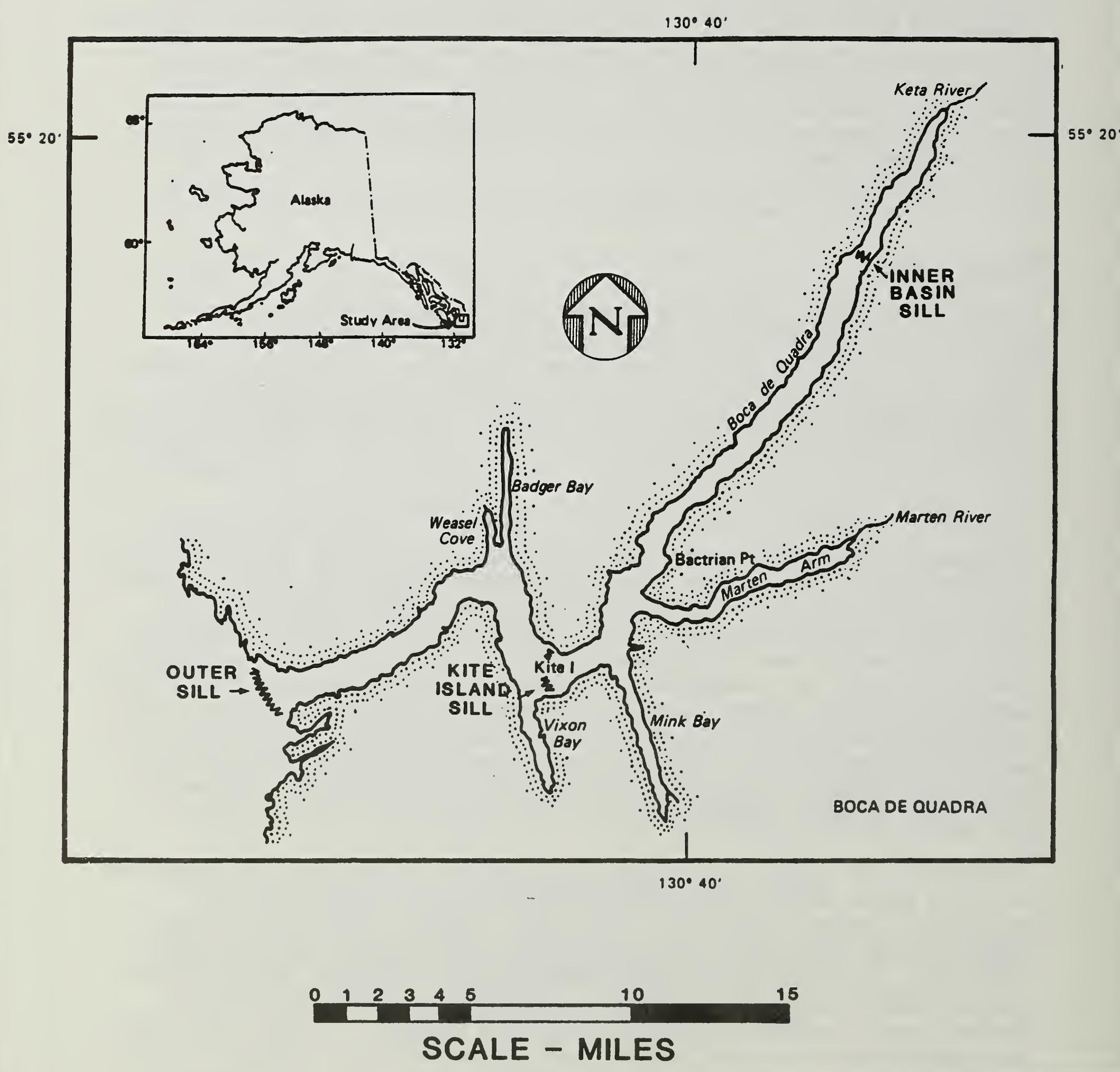
The Smeaton Bay fjord system consists of Smeaton Bay and its northeast extension, Wilson Arm. The small Bakewell Arm extends in an east-southeast direction from the junction of Smeaton Bay and Wilson Arm. These fjords join Behm Canal at the western entrance of Smeaton Bay. Behm Canal in turn joins the Revilla Channel. The Blossom and Wilson rivers enter the head of Wilson Arm. Smeaton Bay is a much smaller fjord than Boca de Quadra. It is characterized by a main basin defined by an outer sill and by abrupt shoaling at the inner end where Wilson Arm and Bakewell Arm are joined. There is a relatively deep sill (about 200 m deep) in the middle of the basin. Figures 3-9 and 3-10 present the Smeaton Bay system and the longitudinal bathymetry of the fjord, respectively.

Major bathymetric features of the fjords are presented in Table 3-7.

Hydrography

The fjords of the Quartz Hill region undergo seasonal and annual cycles. During winter the water column exhibits weak but still significant stratification. As summer approaches the density of deep waters outside the fjord increases in response to a relaxation of coastal downwelling in the Gulf of Alaska. When dense waters arrive at the depth of the Boca de Quadra outer sill, deep water renewal begins. Dense seawater is advected over the sill and into the outer basin. This water rapidly mixes with resident outer basin water. A compensating outflow at sill depth is enhanced. Deep water renewal continues in the outer basin until the density of water at the depth of the Kite Island sill allows deep water renewal to begin in the central basin. High salinity water pulses into the central basin with the flood tide. Deep water renewal in the central basin begins with the sill depth waters and progresses downward as outer basin salinities continue to increase throughout the summer. In the central basin, deep water (below sill depth) becomes nearly vertically homogeneous during the deep water renewal process. Central basin densities increase until August-September. At that time, deep dense waters outside the fjord recede in response to an increase in coastal downwelling, halting the deep water renewal process.

Throughout the winter the central basin water densities slowly decrease as basin water mixes with overlying waters. The location of the pycnocline deepens and at the same time, becomes less well defined. Tides provide the energy for this mixing. The central basin becomes relatively isolated until commencement of the next deep water renewal season. The outer basin remains in good contact with the Revilla Channel and in essence is being constantly renewed. During the winter the central basin is more saline than the outer basin. Salinity and density differences between the two basins result in an outflow over



LEGEND

~~~~ SILL

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-7
BOCA DE QUADRA FJORD SYSTEM	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE BURRELL (1983) DATE JUN 83	
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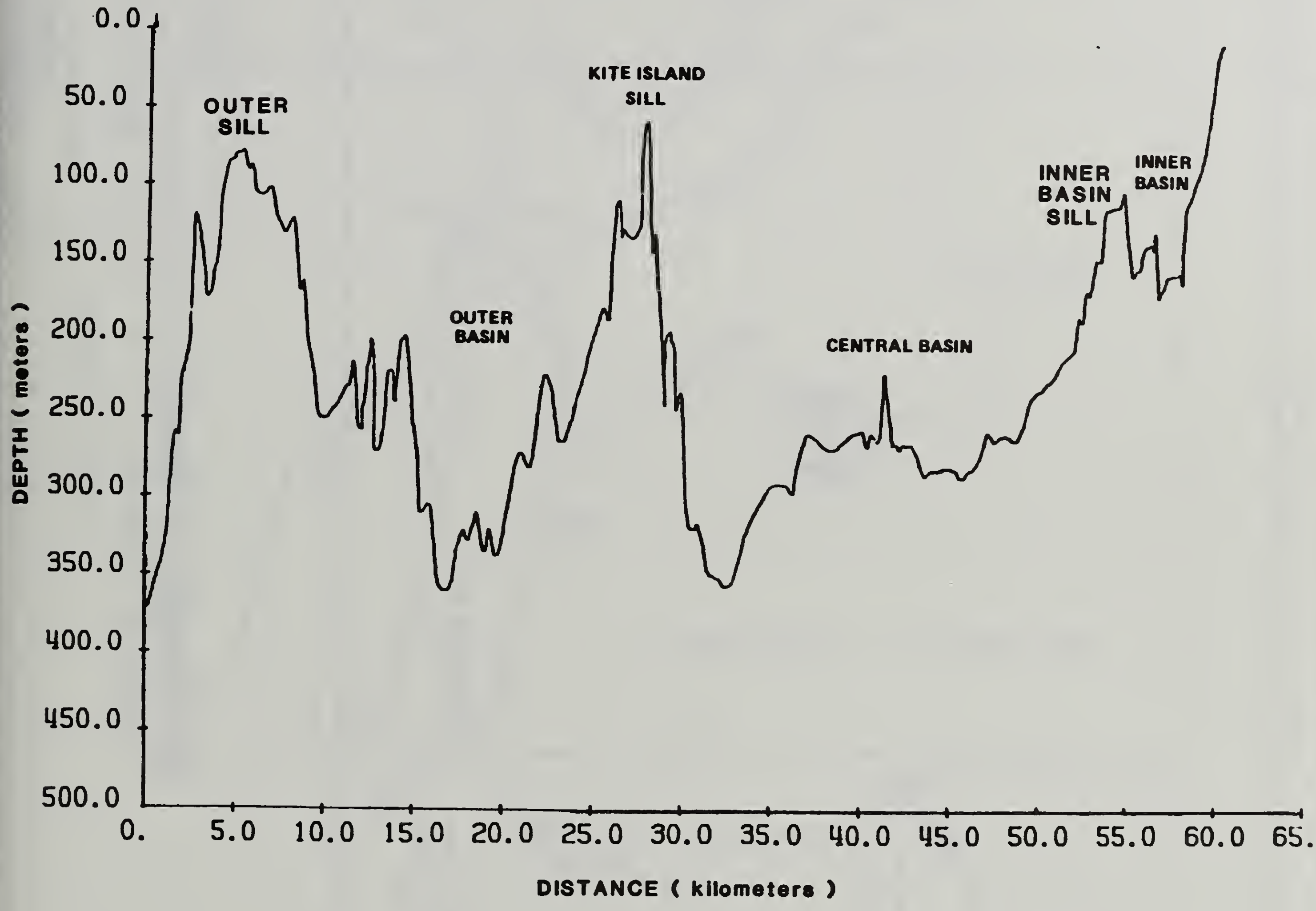

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

BOCA DE QUADRA LONGITUDINAL
BATHYMETERIC SECTION

SOURCE BURRELL (1983) DATE JUN 83

FIGURE
3-8

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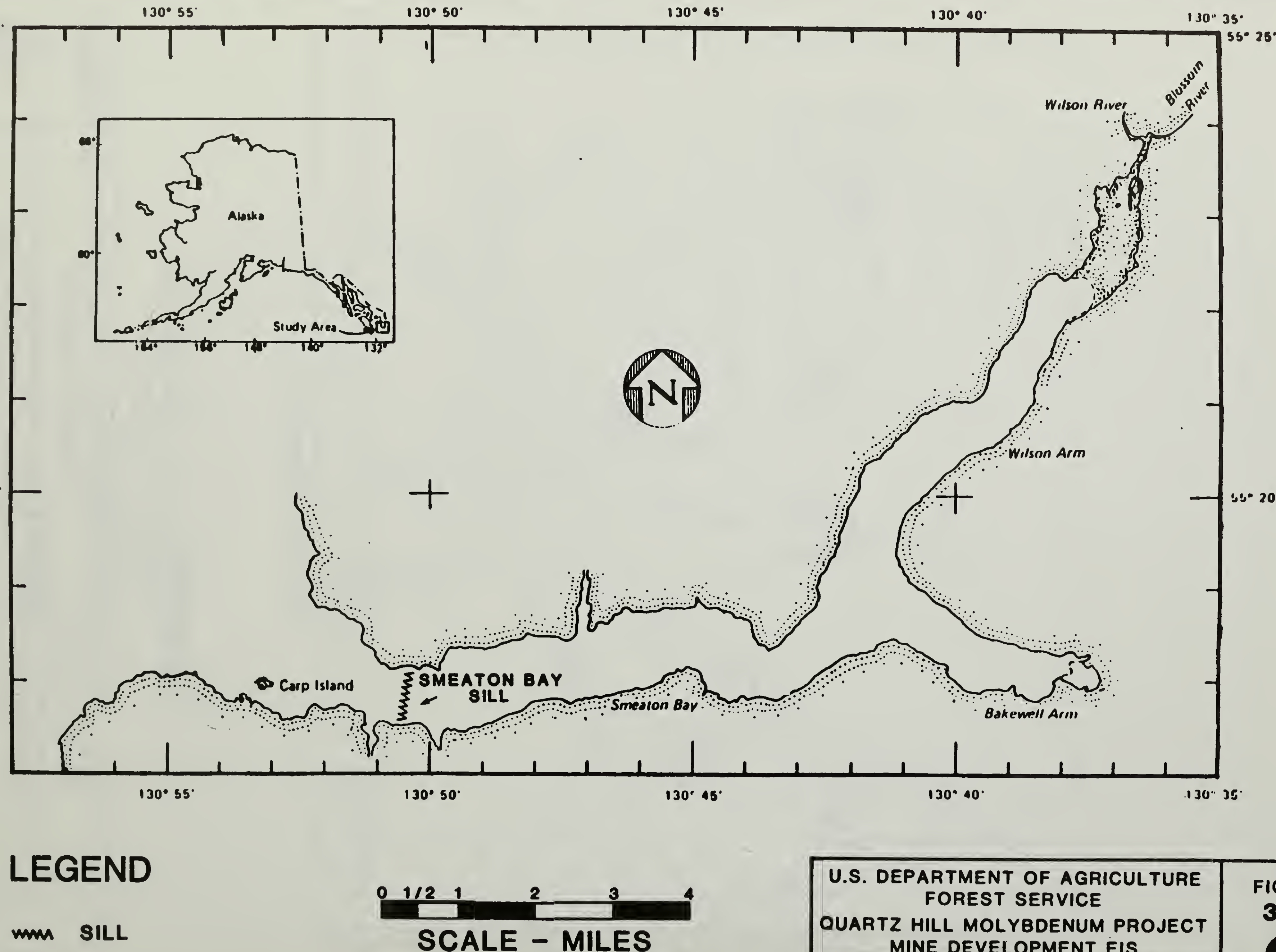

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

SMEATON BAY - WILSON ARM FJORD SYSTEM

SOURCE BURRELL (1983) DATE JUN 83

FIGURE 3-9

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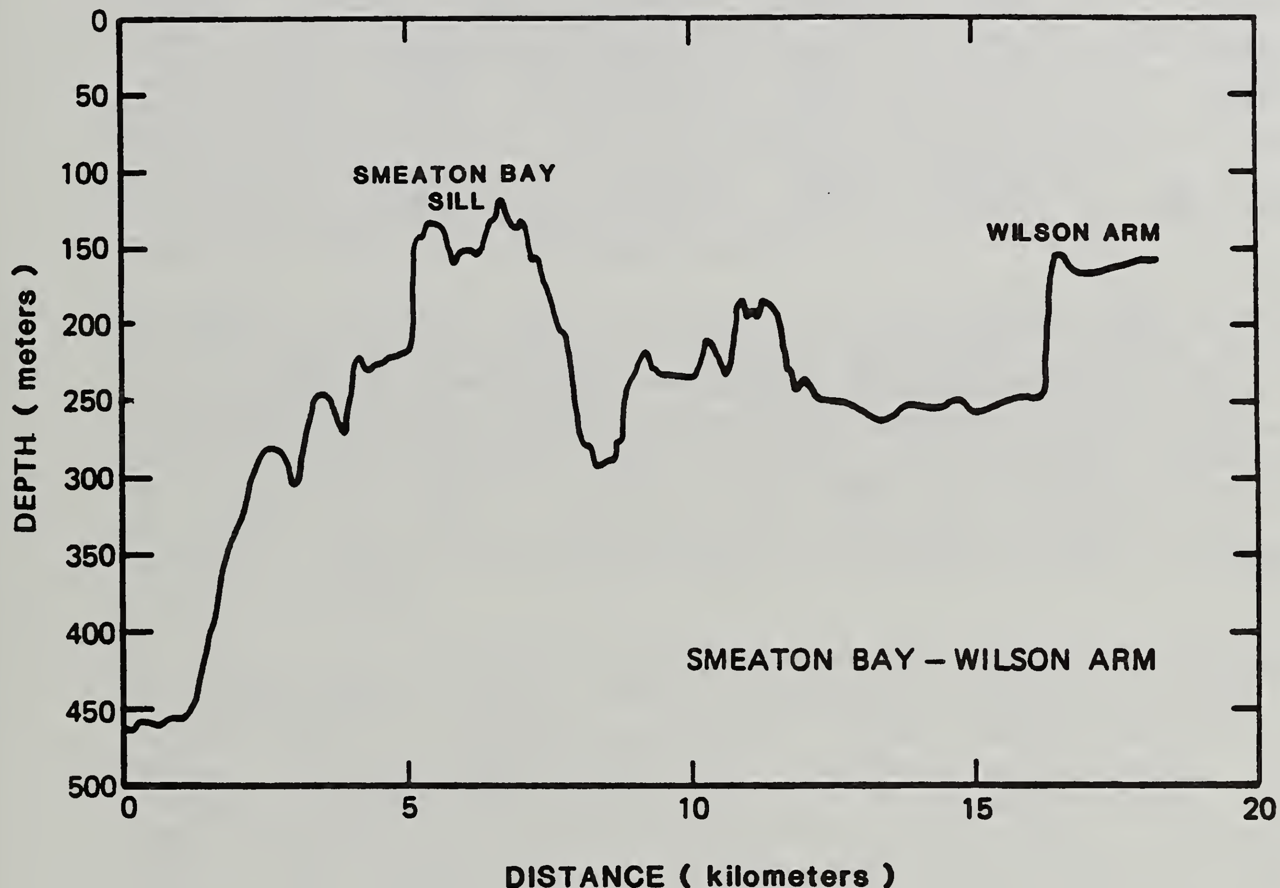


U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-10
SMEATON BAY LONGITUDINAL BATHYMETRIC SECTION	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE BURRELL (1983) DATE JUN 83	

TABLE 3-7

QUARTZ HILL FJORD CHARACTERISTICS

Fjord/Basin	Length (km)	Sill Depth (m)	Maximum Basin Depth (m)	Volume Below Sill-Depth (million m^3)
Boca de Quadra				
Outer	20	85	370	
Central	33	85	390	4300 1/
Inner	7	105	170	100
Smeaton Bay	20	130	295	777 2/

1/ Ryan 1983a, p. 18.

2/ Based on calculations from Professional Design Resources 1985.

the Kite Island sill at sill depth. This outflow becomes a source of denser water for the outer basin. The inner basin deep waters, closely tied to the sill depth circulation, increase in temperature and decrease in salinity as upper inner basin waters are mixed downward. Inner basin sill depth outflow contributes to the waters being mixed downward in the central basin. The beginning of the next deep water renewal period initiates mixing within the fjord and dissipates the last remnant of the previous deep water renewal.

The central basin deep waters are renewed by summer intrusions over the Kite Island sill. Renewal does not appear to be an annual event (Nebert 1985, p. 24). In 1983, deep water renewal never fully developed. During the time when major renewal generally occurs, no deep water renewal was seen below 150 m (Nebert 1984, p. 25). Below-normal upwelling will likely be followed by normal basin renewal. However, basin waters will be replaced with water that is lower in salinity than typically found during a normal renewal year (Nebert 1985, p. 23). Without deep water renewal, salinities in the deep central basin will be relatively low at the beginning of the winter isolation period. Continual downward mixing of overlying waters will further reduce basin salinities. At the beginning of the following deep water renewal period, stratification in the central and inner basin will be exceptionally weak.

In Smeaton Bay bottom water exchange is an intermittent event occurring between April and October and is probably more closely related to tide and storm events. Deep water is advected into the basin as a consequence of higher salinity water being available at sill depth. Vertical density gradients above the outer sill are weaker and the deep basin waters are subject to more gradual deep water renewal. The rest of the year the basin is relatively isolated; water of sufficient density to displace bottom basin water is found well below sill depth outside the fjord.

The upper waters, above sill depths in both Boca de Quadra and Smeaton Bay (approximately 100 and 150 m, respectively) exhibit the lowest vertical density gradients around March. Local processes such as solar heating and higher summer river flows, together with deep water renewal, strengthens the overall stability of the water column. The lowest salinity of the near-surface waters and the highest salinity of the sill depth waters appear at the same time, August-September (Nebert 1983a, p. 9). Thus, the upper water column is most stable during the June through October period. In the summer the pycnocline separates the deep water renewal circulation from the surface circulation. The depth of the pycnocline varies between 40 and 100 m during this period. The summer pycnocline will strongly resist any upward movement of basin waters into the surface layers.

Increased coastal downwelling during the fall deepens the warm near-surface layer. Warm, low salinity, near-surface waters move into

both Boca de Quadra and Smeaton Bay to replace mid-depth outflows. This upper water intrusion penetrates the entire length of the fjord and remains a distinct feature in the head of the fjord throughout the winter. Surface cooling and mechanical mixing (winds and tides) break down the strong summer stratification.

Circulation

In Boca de Quadra and Smeaton Bay the circulation pattern, upper level inflow, and sill depth outflow are the reverse of those in a classic fjord (Nebert and Burrell 1982). Nebert and Burrell (1982) hypothesized this circulation pattern to result from the low ratio of freshwater inflow to the tidal prism. In Boca de Quadra the yearly mean value of this ratio is only 0.5 percent. Even in periods of high freshwater inflow (October) the maximum ratio is 1.8 percent for Boca de Quadra and 4 percent (estimated) for Smeaton Bay (Nebert and Burrell 1982). The driving force for upper water circulation is thought to be brackish water derived from coastal British Columbia, which moves northward up Revilla Channel to the mouth of Boca de Quadra and Smeaton Bay (Nebert and Burrell 1982). Density differences between this regional water and resident fjord water produce the observed circulation patterns.

Major circulation features of Boca de Quadra are the following (Nebert 1984, pp. 32-34):

- Net inflows in the near-surface (10-85 m) waters that are seasonally independent.
- Strong upper water currents in the central basin with frequent direction reversals.
- Sill depth inflow during the early deep water renewal period (the net sill depth flow is downfjord even during deep water renewal), an inner basin sill depth outflow that commences when deep water renewal stops, with a compensation inflow just above sill depth.
- Strong central basin bottom currents (50 cm/sec) associated with deep water renewal.
- Low energy area extending from the upfjord portion of the central basin to the mid-depth waters of the inner basin.
- Light and variable mid-depth currents in the inner basin associated with currents above the inner basin sill.

Major circulation features of Smeaton Bay are the following (Nebert 1985, pp. 18-20):

- Upfjord surface flow and a seasonally dependent circulation pattern in deeper waters.

- Net sill depth outflow that is weakest during deep water renewal.

- Dense renewal water entering the basin with the flood tide.

- Occasional net inflows and outflows at all depths.

- Near bottom outflow in Wilson Arm during most of the year.

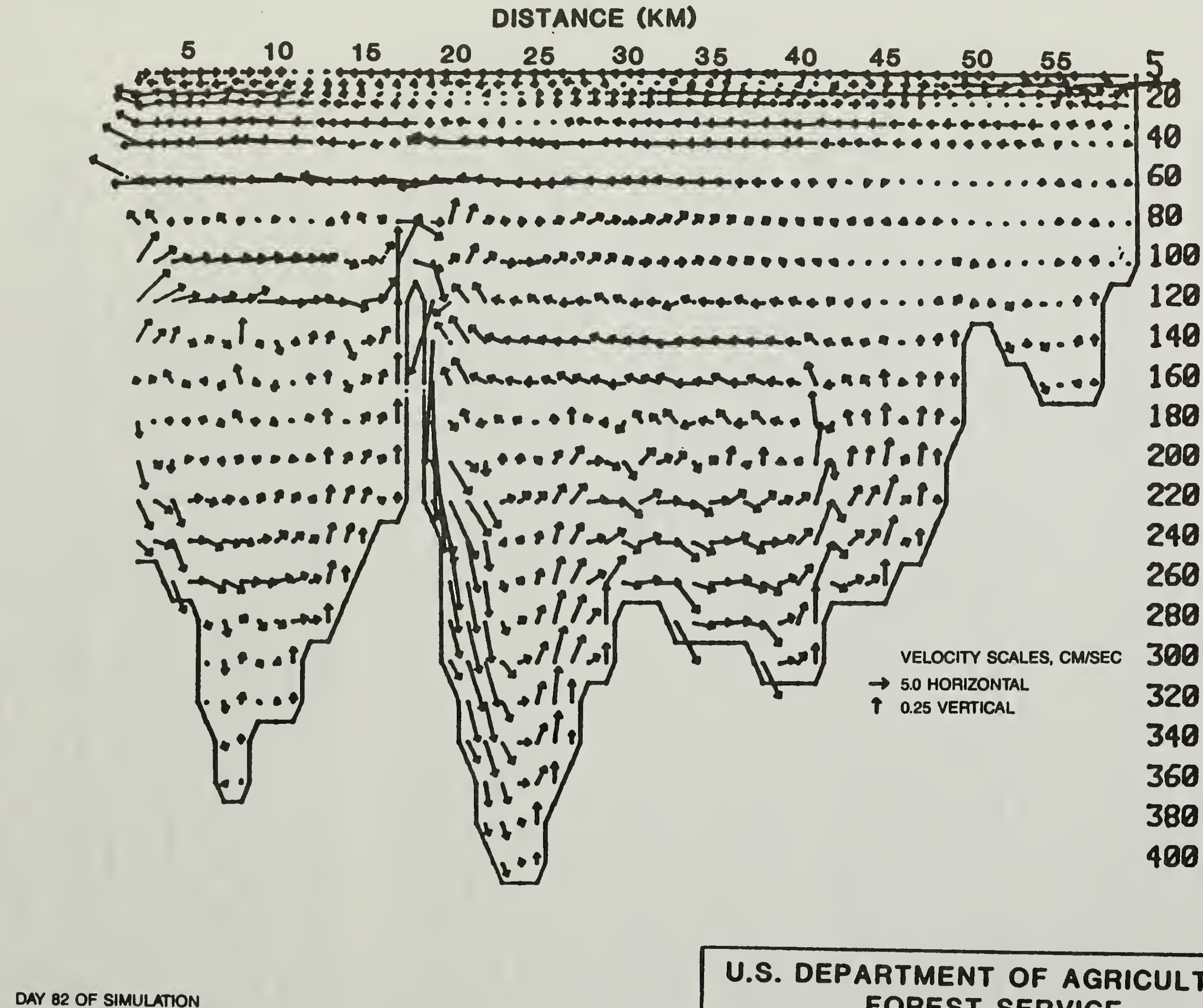
- Persistent weak downfjord bottom current in the inner deep basin during nonrenewal conditions.

- Freshwater input not a significant factor in overall circulation

Surface water responds to freshwater input, winds, and density considerations. In Boca de Quadra upfjord of Marten Arm and in Bakewell Arm, surface waters often are very sluggish and net movement may even be upfjord. Currents in the fjord exhibit frequent directional reversals having tidal periodicities. Maximum current speeds are found in the sill regions; minimum current speeds are found in the deep basins. Mean circulation features for the deep water renewal period resulting from numerical circulation modeling performed for Boca de Quadra (Kowalik 1984, p. 65) are presented in Figure 3-11. The features presented in this figure must be viewed with caution, however, because short-term temporal variability is great enough to reverse most of the features presented in Figure 3-11. For example, counter flows in layers as thin as 10 m are common in the fjord. Such transient features contribute to the complexity of the system and make generalizations nebulous at best.

Currents above the outermost sill of Boca de Quadra are representative of circulation in the Revilla Channel and not the flow near the mouth of the fjord. Subsurface flows in the outer basin appear to be dominantly inward. Currents in the basin at the depth of the outer sill are primarily outflows. Just below sill depth net currents are generally inward and contribute to the nearly continuous renewal of the outer basin.

The Kite Island area is situated on a bend in the fjord, which complicates the current patterns. To the southwest of Kite Island is an east-west channel and to the east of the island is a north-south channel. There is typically strong net outflow above the sill in the southwest channel and strong net inflow at sill depth in the eastern channel. These flows are compensated by slower flows in the opposite direction above each channel. Currents through the Kite Island sill area generally reverse with tidal frequency. This allows deep water renewal to occur with flood tides, despite the fact that the net flow may be outward. High water velocities (50-100 cm/sec) are common with peak current speeds on the order of 120-140 cm/sec (Nebert 1984, p. 17).



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PRE-MINE BOCA DE QUADRA CURRENTS COMPUTED BY TIDE AND DENSITY CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE 3-11

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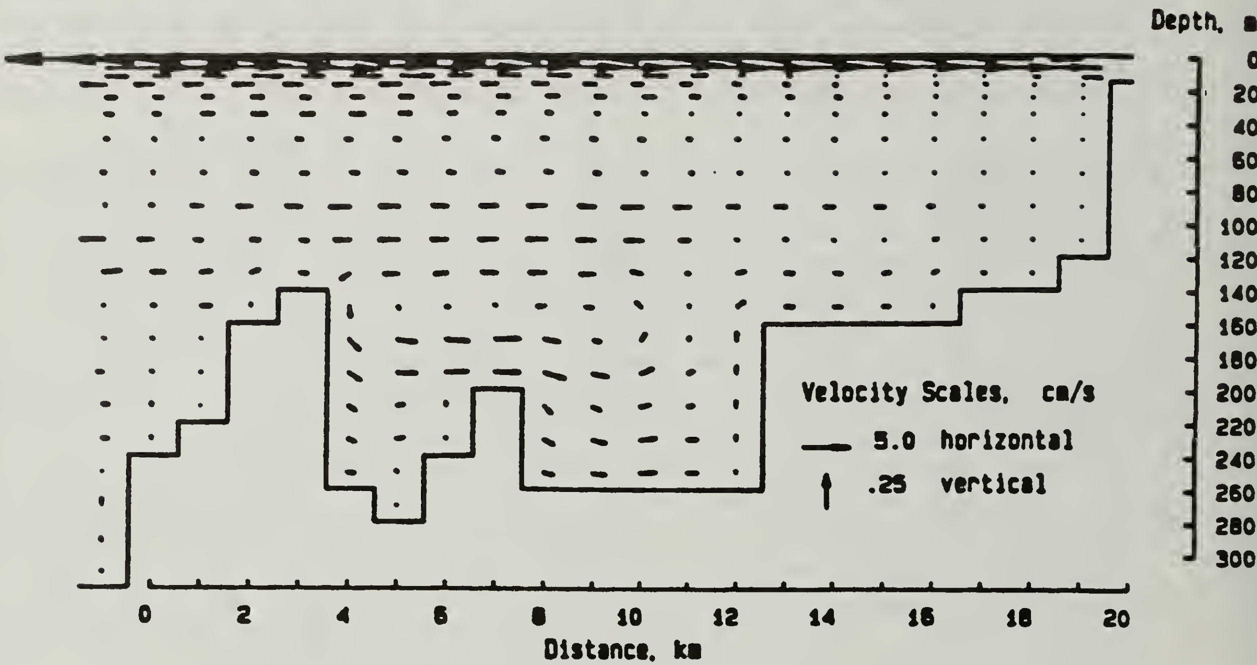
Currents in the central basin tend to be smaller than currents in the outer basin and have a strong semidiurnal tidal component. Sill depth currents are upfjord during the early phase of deep water renewal. Upper basin waters are replaced first during the deep water renewal process. For the rest of the year net flow at sill depth is outward. The deep waters of the basin are quiet except for deep water renewal events. These events take the form of currents, which sweep down the inside slope of the Kite Island sill to a level where the incoming water is neutrally buoyant. Later in the deep water renewal period, current events are seen at the bottom of the basin with peak current speeds of up to 50 cm/sec (Nebert 1984, p. 33). Currents at the bottom of the basin are generally stronger than most of the overlying basin.

Outflow just above the inner sill starts about October and continues through April of the following year. This outflow correlates with the cessation of deep water renewal. For the remainder of the year the flow is oscillatory and at a lower average speed. Peak currents in the inner basin (40 cm/sec) appear to be related to deep water renewal (Nebert 1983a, Appendix D). Mid-depth waters of the inner basin and the upfjord portion of the central basin are relatively stagnant during the nondeep water renewal period (Nebert 1984, p. 33). It is extremely difficult to ascertain current direction in this region. Near surface currents have the largest mean speed (50 hr average of 5 cm/sec [0.2 ft/sec]) in the inner basin. Intermediate depth currents are weaker and exhibit a definite outflow at the depth of the inner sill. Inner basin waters below sill depth appear to be part of the above sill circulation (Nebert 1984, p. 33) and are "swept out" with the sill depth outflow. Inflow of water in the layers immediately above the depth of the sill compensate the sill depth outflow.

Upper layer circulation in Smeaton Bay is more variable than that of the outer basin of Boca de Quadra. Since Smeaton Bay is farther from the source of brackish water, it is more affected by other factors such as local winds, tides, or freshwater input. The general circulation in Smeaton Bay is thought to be the same as found in Boca de Quadra (Nebert and Burrell 1982). General circulation features of Smeaton Bay/Wilson Arm, as predicted by numerical modeling for the 1981 summer renewal period, are presented in Figure 3-12. A general upper level inward flow above 40 m is compensated by an outward flow between 40 and 100 m. There is a net outflow in the form of an oscillating current at the level of the Smeaton Bay sill. Peak current speeds at sill depth (50 cm/sec) are often associated with outflows (Nebert 1985, p. 17). Deep water renewal begins as sill depth water enters Smeaton Bay in the flood tide. Net currents throughout Wilson Arm tend to be small. Downfjord flow may be found in the bottom of the basins during nonrenewal periods.

Analysis of along-fjord current velocities and water level measurements indicates that the semidiurnal lunar tidal component dominates (Nebert 1983a). Tidal range in the fjord is large, from 5 to 7 m (Nebert 1985,



DAY 80 OF SIMULATION

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PRE-MINE WILSON ARM/SMEATON BAY CURRENTS COMPUTED BY THE TIDE AND DENSITY DRIVEN CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD

SOURCE KOWALIK AND FINDIKAKIS (1985) DATE MAY 85

FIGURE 3–12

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p. 21). The largest estimates of tidal currents are found in the region of the Kite Island sill just below sill depth. Large internal tidal waves are observed in the salinity time series data (Nebert 1983a, Appendix A). Amplitudes larger than 25 m at a depth greater than 70 m have been observed. A shift in phase between the upper and lower water velocity is indicative of internal tidal waves that develop because of the density structure. These tidally induced currents contribute to mixing within the fjord. Breaking internal waves may also provide energy for vigorous vertical mixing. However, existing data do not show any evidence of observed internal waves breaking within Boca de Quadra (Nebert 1983a, p. 8).

Wind stress also produces a component of the circulation within the fjords. Because of the height of the surrounding terrain, winds are directed topographically and channeled up or down the fjords. In the Boca de Quadra area, the wind direction is predominantly downfjord, with upchannel wind occurring less than 30 percent of the time at the head of the fjord (VTN 1982a, pp. 13-19). Upfjord winds may have slightly greater speeds than downfjord winds. Winds that blow downchannel result in slight increases in water density as surface water is removed from the head of the fjord and replaced by deeper upfjord flow (Nebert 1985, p. 22). Wind events are expected to be most important in the winter and spring seasons when freshwater input into the fjord is low.

Sediments and Sedimentation

The two major sources for sedimentation in the fjords are freshwater inflow and *in situ* production (for example, phytoplankton blooms or precipitation-flocculation of soluble and colloidal material). Significant quantities of particulate material are not carried into Boca de Quadra and Smeaton Bay from waters outside of the fjord. The estimated annual suspended sediment load transported into Boca de Quadra by the Keta River alone is 25.8 million kg (31,400 tons). The estimated annual suspended sediment load transported into Wilson Arm by the Blossom River is 30.8 million kg (34,000) (VTN 1984, p. 57).

The combined flow of the Keta, Marten, and Red rivers represents 70 percent of the fresh water entering Boca de Quadra upfjord of the Kite Island sill. The combined Wilson and Blossom rivers represent only 56 percent of the fresh water entering the Smeaton Bay system (Burrell 1983, p. 2-7).

Particulate concentration maxima in the waters above sill depths coincide with or lag periods of maximum river volume discharge, resulting in a bimodal spring-fall pattern. Near-surface layers of the fjords are well stratified during the spring and fall. Therefore, surface turbidity plumes are expected to develop only during periods of very high rainfall and runoff. Because river-driven surface flow is weak in Boca de Quadra and Smeaton Bay, turbidity plumes are significant only near areas of large freshwater discharges.

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In general, surface concentrations of particulate matter do not exceed 1-2 mg/l except for periods of high river discharge. Surface loads toward the head of the fjords are slightly enhanced on ebb tides and decrease on flood tides. Minimal concentrations typically occur at a depth of about 50 m. Below sill depth particulate concentrations are nearly uniform year round, with values around 0.3 mg/l. Slight maxima occur in the basins in late summer and early fall (Burrell 1983). Slight variations in bottom concentrations are detected over tidal cycles. Maximum near bottom particulate concentrations in the fjord basins are most likely associated with slumping resulting from slope instabilities. In the central basin of Boca de Quadra, near bottom particulate maxima also result from lateral transport from Marten Arm and Mink Bay. Scouring of the bottom has been observed in the shallow reaches of the inner basin of Boca de Quadra and throughout Smeaton Bay. Sediment resuspension is generally absent except for events associated with deep water renewal when high speed currents occur adjacent to the central basin sill slope.

Data based on core samples obtained in Boca de Quadra and Smeaton Bay establish a sedimentation rate for various locations in the fjords (Burrell 1983). Upfjord of the Boca de Quadra central basin sill, deposition rates are 1.0 cm per year (0.2 g of sediment per sq cm per year). Furthermore, this rate has been relatively uniform over the past 30-40 years. Inside the Boca de Quadra inner basin sill, sedimentation rates are also high, 0.9 cm per year (0.5 g per sq cm per year). However, here the sediments appear highly disturbed. In Smeaton Bay early in 1981, a slumping event redistributed up to 11 cm of new material. Prior to this event the sedimentation rate near the head of Smeaton Bay was 0.4 cm per year (0.1 g per sq cm per year).

3.1.7 Chemical Oceanography

The two fjords that may be affected are Smeaton Bay, including Bakewell and Wilson arms, and the central and inner basins of Boca de Quadra. The configuration and longitudinal bathymetry of these fjords are presented in Figures 3-7 through 3-10.

Chemical oceanography programs were established by the University of Alaska to set a baseline for marine water quality and sediment quality in the fjords (Burrell et al. 1980; Nebert and Burrell 1982; Nebert 1983a, 1983b; Burrell 1983). In general, the water quality of both fjords is similar and of the high quality typical of uncontaminated coastal and estuarine water bodies of southeastern Alaska and British Columbia. The trace metal concentrations are in the range reported for uncontaminated marine water.

Dissolved Oxygen

The distribution of dissolved oxygen within the fjords follows the annual large-scale water circulation patterns. Maximum water column oxygen concentrations (8-9 mg/l) are found within the euphotic zone at the time of the spring bloom. The mixed layer (above the sill) of both fjords is close to saturation or super-saturation year round. Within the deep basins, concentrations are highest during the summer when new

water enters the basins. During the winter, the deep basin water is isolated from the water above or outside the sill and is therefore not advectively replaced; however, anoxic conditions are not approached in the water column and adequate oxygen is available for marine life.

Winter oxygen concentrations at the bottom of both the Boca de Quadra middle and inner basins did not fall below 2.5 mg/l during the study period. The maximum decline in oxygen was only about 0.5 mg/l from the value established at the end of the summer flushing period.

Annual oxygen concentration patterns within the Smeaton Bay deep basin are similar to those in Boca de Quadra. However, the dissolved oxygen content of the basin is less at the end of the summer than in the central basin of Boca de Quadra. Minimum winter concentrations in Smeaton Bay are less than 2.5 mg/l. There are year-to-year variations, but there is no indication that natural conditions would produce anoxic conditions. The lower oxygen concentrations observed in Smeaton Bay are most likely due to the deeper barrier sill at the entrance of Smeaton Bay. As a result of the deeper sill, deeper oceanic waters with a lower oxygen content flush the basin.

There is an apparent trend (1979-1982) to increasingly lower minimum oxygen concentrations in the deep basins of the fjords each winter. This trend may be a systematic cycle related to processes occurring in the deeper waters outside of the fjord. Oxygen concentrations in water outside the outer Boca de Quadra sill had a dissolved oxygen concentration less than 2 mg/l during the summer of 1982. Presently available time series are too short to identify systematic cycles in winter oxygen concentrations that are greater than one year. However, the apparently natural trend of decreasing minimum oxygen concentrations may result in lower dissolved oxygen concentrations than have been recorded to date.

Carbon and Nutrient Cycling

Organic carbon input to Boca de Quadra and Smeaton Bay is derived primarily from river borne input and *in situ* primary production. Solid phase (particulate and bed load) detrital carbon does not appear to fuel biological production to any extent in the fjords as the burial rate of carbon in the sediments is on the same order of magnitude as the estimated riverine influx. The largest fraction of riverine organic carbon is dissolved organic matter (DOM). The fate of the riverine DOM within the fjords is not well known. Some fraction, probably minor, will flocculate and settle, the remainder is likely to behave conservatively within the estuarine environment.

Primary productivity within the fjords is characterized by a spring phytoplankton bloom. This event spans a few weeks or less between late March and early May. Although brief, this bloom accounts for 40 percent of the integrated annual primary production. During the spring months, the nutrients in the surface layer are replenished from the deep water reservoir. The exact mechanism of this replenishment is not known; however, Burrell (1983, Chapter 4, p. 28) states that in a near-homogeneous water column, relatively rapid upward mixing would be

expected to replenish nutrient levels. These nutrients are available to fuel the spring bloom, which is believed to be initiated by increasing sunlight. Nutrient depletion is believed to be the primary cause for termination of the initial bloom. This nutrient depletion is attributed to increased water column stability, which restricts replenishment from below. Additionally, deep water renewal begins in spring with oceanic waters from intermediate depths, which have relatively low nutrient concentrations. This results in a partial or total loss of high nutrient water out of the fjord around May-June. As the deep water renewal process continues through the summer, deeper nutrient rich oceanic waters flush the deep basins and nutrient concentrations increase at depth. This pattern is exhibited in both fjords. Deep water replacements commence earlier in the year in Smeaton Bay and continue longer into early winter as a consequence of the deeper sill at the entrance of this fjord.

Nutrient concentrations in the euphotic zone through summer are sustained at low levels by nutrient release from the initial bloom. In late summer nutrient concentrations increase again and fuel a secondary phytoplankton bloom. This is due in part to increased riverine supply, particularly of ammonia as a result of decaying salmon. This is the only time of the year that riverine nutrient input appears to be important for primary production. Increased mixing of the near-surface layer through this season must also transport in "new" marine supplies from the deeper basins. As discussed for surface nutrient replenishment during spring, the mechanism of this transport has not been determined.

The major factors affecting mean seasonal nutrient concentrations in the deep basins are transport out of the sediments and the advective renewal of basin water described above. Quantitatively, renewal is the more important process. The natural flux of nutrients from the basin sediment is initially computed to be less than 20 percent of the annual requirements in the overlying euphotic zone (Burrell 1983, Chapter 5, p. 27).

Trace Metals

Heavy metal concentrations of the river water entering the fjords are low but their specific levels are not well known. Available data have been discussed in Section 3.1.5.

Much of the dissolved river-borne trace metals may be expected to be redistributed to the solid phase in the freshwater/seawater mixing zone and eventually be removed to the sediments. This may be attributed to the mixing of low alkalinity river water with the higher pH seawater, which tends to decrease the solubility of trace metals (Bourg 1981, p. 207; Forstner 1980, p. 249), the flocculation of colloidal or semicolloidal particles (such as humic compounds and clays) (Forstner and Wittman 1979, p. 192), and the formation of Fe and Mn hydroxides (Forstner and Salomons 1981, p. 251). Formation of flocculates and Fe and Mn hydroxides provide additional particulate surfaces for the

adsorption of dissolved trace metals (Forstner 1980, pp. 245-253; Lee 1973, p. 146; Duinker 1980, pp. 130, 134). Most dissolved constituents that are not removed in the mixing zone will be removed from the water column by adsorption and precipitation reactions as they are transported downfjord. Only those elements that form strong anionic complexes may be transported out of the estuary in dissolved form (Duinker 1980, p. 143). Arsenic, chromium, selenium, and molybdenum form anionic complexes and therefore would be expected to remain dissolved. Some studies indicate that Mo may be removed from the dissolved phase (Burrell 1981, p. 267). However, a removal mechanism has not been consistently demonstrated.

Available trace metal concentrations for Boca de Quadra (September 1983) and Wilson Arm/Smeaton Bay (October 1981) are compared with concentrations reported for other coastal and open ocean areas in Table 3-8. Although the concentrations were determined by a variety of test methods, they are all within the generally expected range for seawater. In the open ocean, total concentrations of trace metals can be considered as nearly equivalent to dissolved concentrations due to low levels of suspended matter (Forstner and Wittman 1979, p. 86). In nearshore areas and in the freshwater/seawater mixing zone where suspended solids concentrations may be elevated, higher metal content in the solid phase may be expected.

Sediment Composition

The sedimentation rates within the main basins of the two fjords presently appear to fall in the range of 0.1 to 1.0 cm/year (Burrell 1983, Appendix 2, p. 10). For the few deep cores dated so far, there is no evidence for extensive bioturbation of the deep sediments. Within the Boca de Quadra middle basin, sediments are fine grained, silty clay, with a porosity of around 0.75 and contain about 4 to 5 percent particulate organic carbon (POC) (Burrell 1982, p. 138). Sediment within the inner basin is, on average, significantly coarser. Sediment size fractionation data for bottom sediments of the Wilson Arm/Smeaton Bay fjord system are not available; there is, however, no reason to suppose that grain size distribution will be radically different than that of Boca de Quadra (Burrell 1982, p. 137). The primary difference noted between Boca de Quadra sediments and those found in Wilson Arm/Smeaton Bay is the slightly lower organic content of the Wilson Arm/Smeaton Bay sediments. Mean POC content of the Wilson Arm/Smeaton Bay sediments is 3-4 percent. This difference is slight and may possibly disappear when additional data have been obtained (Burrell 1982, p. 138). In both fjords the surficial sediment is compact and the interface is sharp. Given such characteristics, a mechanically cohesive sediment (one not easily resuspended at moderate current shear) would be expected.

TABLE 3-8

COMPARISON OF TRACE METAL CONCENTRATIONS IN
BOCA DE QUADRA AND SMEATON BAY WITH OTHER
COASTAL AND OPEN OCEAN DATA
(All concentrations in µg/l)

Metal	Boca de Quadra1/	Wilson Arm/ Smeaton Bay (concentrations)2/	Alice Arm and Observatory Inlet, BC1/	Saanich Inlet, BC1/	Compiled Oceanic Data3/	Typical Uncontaminated Seawater (total)4/
Cu	0.170-0.270	0.150-0.400	0.190-0.360	0.150-0.600	0.040-0.1(surface) 0.140-0.8005/	0.30
Cd	0.028-0.065	0.02-0.109	0.025-0.110	0.020-0.080	0.01-0.07	0.08
Pb	<0.005-0.016		0.0005-0.001	<0.001-0.010	0.001-0.015	0.01
Zn	<0.120-0.300		0.100-0.900	0.020-0.800	0.010-0.600	0.50
Cr	0.120-0.175			0.100-0.200	0.080-0.150	0.15
Ni	0.200-0.350	0.31-0.51	0.400-0.930		0.200-0.700	0.40
Mo	5.0-10.5	6.7-21.4		7.0-10.36/	10	9
As	0.8-1.8				2.1	1.4
Mn					0.2	2.0
Se	0.050-0.170				0.040-0.130	.10
Ag					0.01	0.0027/
Hg	0.003-0.010				0.011	0.0018/
Fe					1.3	1.0

1/ Erickson and Stukas (1983), p. 16.

2/ Burrell (1983), Table 7.5.

3/ Forstner and Wittman (1979), p. 87.

4/ Riley and Skirrow (1965), pp. 164-165

5/ Heggie (1983). For Resurrection fjord, Alaska as reported in Stukas and Erickson 1983, p. 16.

6/ Berrang and Grill (1974). As reported in Erickson and Stukas (1983), p. 16.

7/ May be even lower. Bloom and Crecelius (1984), p. 15.

8/ Bloom and Crecelius (1983), p. 49.

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The vertical concentration gradient of soluble inorganic nutrients in the sediment interstitial water suggests a large flux of these species out of the sediment. Winter distribution patterns confirm that this happens, and that there is a continuous supply of nutrients upward out of the basins. Because of near-surface stratification and advection of the mixed water layer, it is unlikely that basin-derived, regenerated nutrients directly fuel plankton production in the immediately overlying euphotic zone. As previously stated, sediment-derived nutrients provide less than 20 percent of annual nutrient requirements to the euphotic zone. Nevertheless, the supply is added to the local coastal water pool, which drives primary production in the general area.

Mean surficial sediment heavy metal concentrations in Boca de Quadra are 32, <15, 2, 60, 550, <1 $\mu g/g$ for copper, lead, molybdenum, zinc, manganese, and cadmium, respectively (Burrell 1983, Chapter 7, Table 7.20). Sediment metal concentrations in Smeaton Bay are similar to those in Boca de Quadra; however, there does appear to be higher concentrations of Mn in the sediments from Boca de Quadra (Burrell 1983, Chapter 7, p. 21). These concentrations are typical for uncontaminated fine-grained coastal sediments (Dexter et al. 1981, p. 282; Turekian and Wedepohl as reported in Forstner and Witmann, p. 134).

3.1.8 Noise

A background noise survey at the Quartz Hill area was conducted in November 1982 to measure existing noise levels exclusive of construction activity (Nugent 1983, Part 1, Section 2). A program to monitor noise levels caused by the bulk sampling activities was not conducted. The four monitoring sites were located at Bakewell Lake, the mouth of Boca de Quadra, Tunnel Creek valley, and the head of Wilson Arm. The weather was variable during the monitoring period and there was snow cover at Tunnel Creek and Boca de Quadra. The limited activities at the site were not audible, except for brief helicopter noises. The background noise levels, defined as the level exceeded 90 percent of the time, ranged from a low of 32 dBA at Bakewell Lake to a high of 42 dBA at Wilson Arm. Streams and waterfalls were the main contributors to background noise. The measured noise levels are typical of quiet forests (Forest Service 1975, p. 11).

The near-source noise attenuation rate caused by ground cover and trees was also determined during November 1982 by measuring the noise intensities at various distances away from shotgun blasts (Nugent 1983, Part 2). The attenuation measurements were taken in dense forest with some snow cover. The foilage attenuation caused by dense forest within the first 300 ft of sound travel was 4 to 16 decibels depending on the sound frequency. The total near source attenuation measured after 3,000 ft of sound travel was 12 to 26 decibels. For the Quartz Hill operations it is expected that the existing trees will be cleared from the mine site and other facility areas. Assuming that there will be no dense forest near the major noise sources, the expected near-source noise attenuation (occurring after 3,000 ft of sound travel) during the mining phase would be roughly 8 to 10 decibels.

3.1.9 Hazards Susceptibility

Seismicity

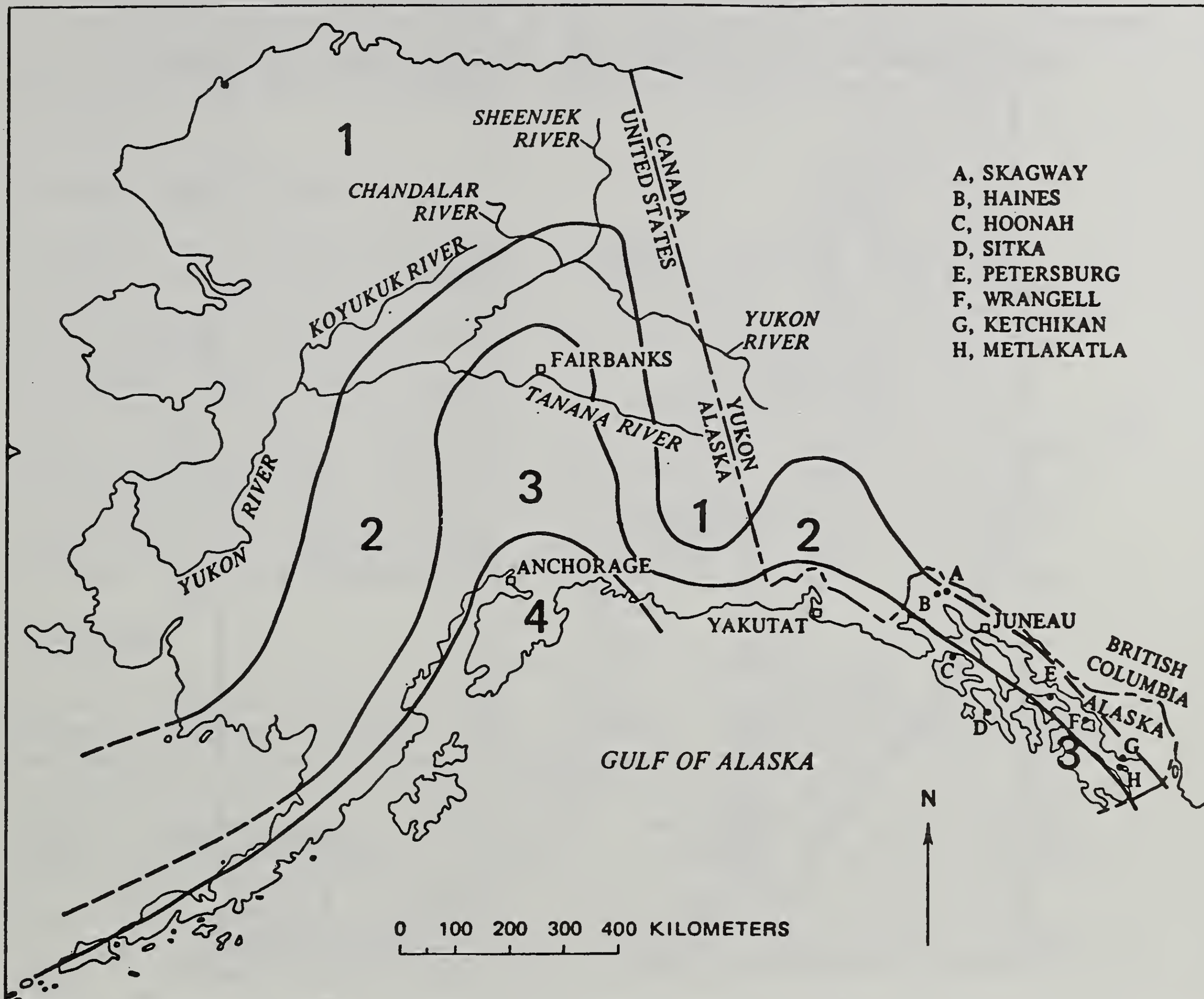
The project area is within the seismically active Circum-Pacific Belt. According to the seismic zone map of Alaska (Uniform Building Code), the site lies within seismic zone 1 near the boundary of seismic zone 2 (Figure 3-13). This seismic zone map relates a particular zone to the Modified Mercalli intensities expected to affect the zone. Zone 1 includes areas subject to minor damage to structures resulting from earthquake effects of intensity V and VI on the Modified Mercalli Scale. Zone 2 includes areas subject to moderate damage resulting from earthquake effects of intensity VII on the Modified Mercalli Scale. Projected maximum earthquake intensity in the project area is approximately VII (Meyers et al. 1976, Figure 7a), which would indicate that the site is more appropriately within seismic zone 2. Earthquake felt reports indicate the maximum intensity for Ketchikan was V on the Modified Mercalli Scale from a magnitude 7.6 earthquake 187 mi away, on July 30, 1972 (Meyers et al. 1976, microfiche). The great Alaskan earthquake of 1964 had an intensity in Ketchikan of about III on the Modified Mercalli Scale and was not reported to have been felt in the area (Meyer 1976, p. 8, Fig. 3).

The Clarence Strait Lineament, about 55 to 60 mi west-southwest of the site, has been identified as a potential fault zone. No known earthquakes are associated with this lineament (Forest Service 1981a, p. 3-10). Most of the severe earthquake epicenters are 150 to 200 mi from the site (Figure 3-14). The largest earthquake on record in the region occurred in 1949 along the Fairweather-Queen Charlotte Fault, approximately 160 mi from the site (number 7 on Figure 3-14). This earthquake had a magnitude of 8.1 on the Richter Scale. No earthquake intensity was reported; however, damage did occur about 50 mi from the site at Prince Rupert, B.C. (Sanders 1983, p. 1-9).

Preliminary seismicity evaluations indicate the maximum earthquake acceleration would probably be due to a magnitude 6.5 event on the Clarence Strait Lineament or a magnitude 8^+ event on the Fairweather-Queen Charlotte Fault (Forest Service 1981a, p. 3-10). Estimates of lateral acceleration at the site range from 0.06 (Sanders 1983, p. 1-11) to 0.10 (Forest Service 1982a, p. 3-10) times the acceleration of gravity (g). The 100-year probability map showing the peak acceleration from earthquakes indicates that the site is in an area that would have a peak acceleration of 10 percent of gravity (Yehle 1979, p. 26, Figure 6).

IECO determined through their investigations of regional seismicity and faulting that there is no evidence of movement along any of the faults within the project area since the last glacial period 10,000 years ago (IECO 1981, p. 2-2). The orientation of the Stephens Fault is

SEISMIC ZONE MAP OF ALASKA

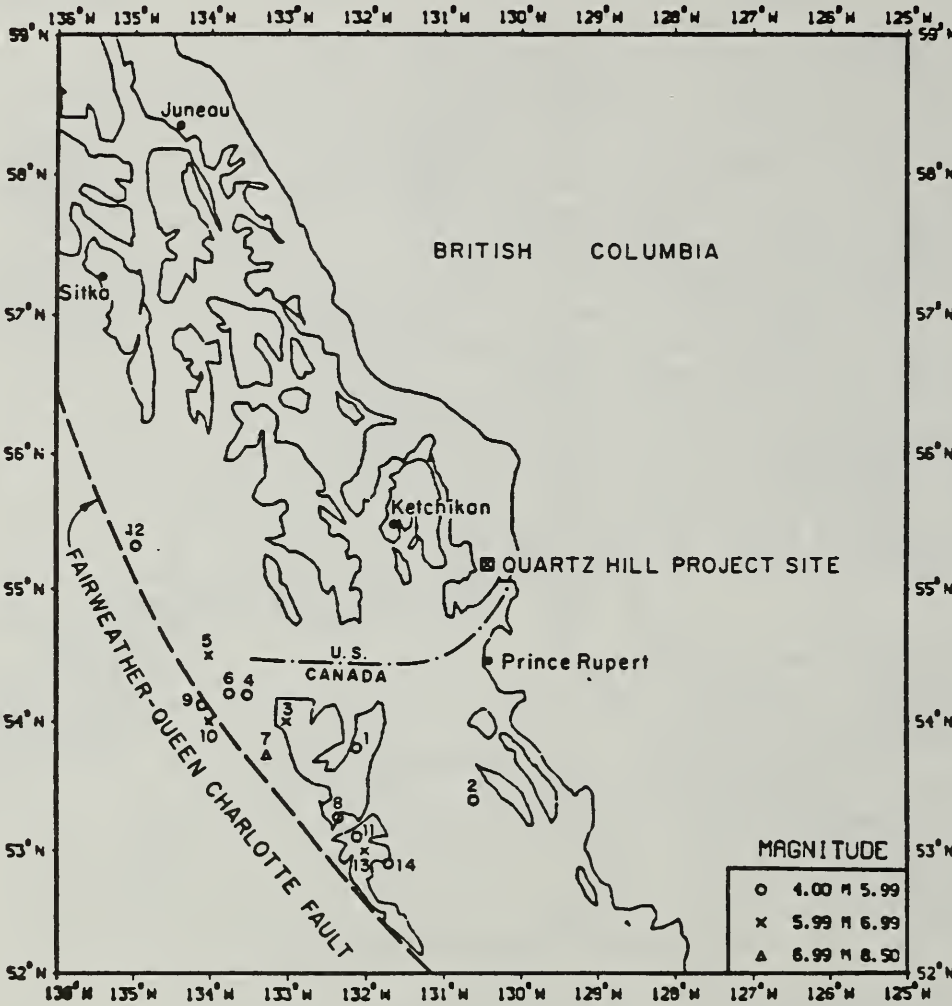


EXPLANATION

Zone	Damage	Comment
1	Minor	Distant earthquakes may cause damage to structures with fundamental periods >1.0 s; corresponds to intensities[1] V and VI
2	Moder-ate	Corresponds to intensity[1] VII
3	Major	Corresponds to intensity[1] >VIII
4	Major	Those areas within zone 3 determined by proximity to certain major fault systems

[1] Modified Mercalli intensity scale

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-13
SEISMIC ZONE MAP OF ALASKA	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE DATE	



Earthquake Activity within 300-Km Radius of the Quartz Hill Project.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-14
EARTHQUAKE ACTIVITY WITHIN 300 km RADIUS OF THE QUARTZ HILL PROJECT	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE INT ENGINEERING DATE OCT 83	

essentially the same as the orientation of active faulting along the continental edge of southeastern Alaska (VTN 1977, p. 5-13). The project area is well separated by distance from the active faulting zone to the west and the area to the east is quiescent (VTN 1977, p. 5-15). Subsidiary movement in the local area may occur as a result of an earthquake along the active faulting zones to the west. Evidence in the project area suggests that the potential for damage from avalanches set off by earthquake shocks is significant (VTN 1977, p. 5-17).

Tsunamis and Seiches

Tsunamis could occur as a result of seismic activity along the Fairweather-Queen Charlotte Fault. For example, the 1949 earthquake produced a wave 0.33 ft in height at Ketchikan. However, it appears that damaging tsunamis are more likely to originate as a result of earthquakes near coastal southcentral Alaska. The great Alaskan earthquake of 1964 produced a maximum runup of 2.0 ft at Ketchikan (Cox 1976, p. 28). Seiches from this earthquake were not affected by either direction or distance from the epicenter. The largest seiche (3 ft) was reported in a very large reservoir in southern British Columbia. Some stream level gages in the Ketchikan-Wrangell area registered seiches from less than 0.1 ft to 0.5 ft (Sanders 1983, p. 1-12).

Landslides

Slopes in the project area vary from level to vertical, with the majority of slopes greater than 30 percent. Relatively gentle slopes are generally found at lower elevations in the alluvial flats and estuarine areas of the major rivers. Relatively gentle slopes are also found in upland areas, although these are of limited areal extent. Steep slopes (in excess of 30 percent) characterize most of the Quartz Hill region. They are common in the alpine and subalpine areas, in most of the ridgeline areas, along deeply incised, upland streams, and along much of the shoreline of Boca de Quadra, Bakewell Arm, and Wilson Arm.

Landsliding is common in the area (Forest Service 1982a, p. 3-4). A total of 11 construction-induced landslides and rockslides occurred along the Blossom River access road route during construction of the road, resulting in a total displacement of 749,000 cu ft of soil and rock (Lyons 1984). Susceptibility to landsliding or slope failure depends on a number of preexisting conditions within the environment such as drainage patterns, bedrock properties, slope geometry, and vegetative cover (Forest Service 1982b, Appendix G).

Detailed analyses of susceptibility to landsliding were conducted for the bulk sampling road access corridors. Results of these analyses were presented previously (Forest Service 1982a, pp. 4-6 through 4-9, 4-43 through 4-47). The susceptibility to landsliding in the project

area is presented in Figure 3-15. This qualitative assessment of susceptibility to mass movement was made for the area as a whole, based on slope and soil properties. Slopes were measured as the rate of change in elevation per 1,000 ft of horizontal (or map) distance and expressed as a percentage. In general, where slopes were measured at less than 30 percent, an area was assigned a low hazard rating. Where slopes were measured to be in excess of 30 percent, an area was assigned a moderate to high hazard rating. Where slopes were measured to be in excess of 30 percent, and physical properties of soils rendered them particularly susceptible to mass movement, an area was assigned a high hazard rating.

Low hazard areas are generally found at the lower elevations, in the alluvial floodplains of the larger rivers (Keta and Blossom) and streams (Tunnel Creek, Falsegate Creek). On occasion, low hazard areas are found in the upland, subalpine valleys, although these areas are of limited extent. Low hazard areas represent a relatively small percentage of the total land area within the boundaries of the area of study. The balance of the land area has been classified as having a moderate to high, or a high susceptibility to landsliding.

Avalanches

The natural downslope movement of snow is a function of many complex physical interactions encompassing terrain, vegetation, and climatic conditions. Throughout the project area these factors combine to produce a nearly constant, moderate-to-high avalanche hazard at points within general avalanche zones throughout the snow season (Figure 3-16). There are frequent periods of high hazard at all points in these general avalanche zones throughout the winter season (Wilson 1983, p. 9).

Numerous well defined avalanche paths can be seen throughout the project area. Significant avalanche effects on the project during access road construction and bulk sampling have thus far been limited to a single event. In the mid to late 1970s an avalanche originating in 20 Dollar Gulch swept through the site of the original exploration camp carrying debris and breaking trees above and on both sides of the camp (Wilson 1978, p. 6).

Limited observations to date indicate that each of the avalanche zones within the project area may release avalanches of some size at least once during each significant precipitation period and when warming temperatures cause weakening of the snow pack. Destructive avalanches are expected periodically throughout each snow season at each of the more critical (Class 2 and 3) avalanche zones. Class 3 avalanches (major avalanches having great destructive forces) are predicted for the mine pit area and areas immediately surrounding the pit, in the upper Hill Creek area, in the Aronitz valley, and in the Tunnel Creek

LEGEND

- AREA IN WHICH SLOPES ARE GENERALLY LESS THAN 30%, LOW HAZARD AREA.
- AREA IN WHICH SLOPES ARE GENERALLY GREATER THAN 30%, MODERATE TO HIGH HAZARD AREA.
- AREA IN WHICH SLOPES ARE GENERALLY GREATER THAN 30%, AND SOILS HAVE A MODERATE TO HIGH SUSCEPTIBILITY TO LANDSLIDE, HIGH HAZARD AREA.

N

0 1/2 1 2 3 4

SCALE - MILES

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LANDSLIDE SUSCEPTIBILITY

FIGURE 3-15

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SOURCE ENVIROSPHERE DATE DEC 83

N

0 1/2 1 2 3 4

SCALE - MILES

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-16
AVALANCHE ZONES	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE WILSON 1983 DATE SEP 83	

valley. Class 2 avalanches (destructive avalanches) are predicted in areas of the Hill Creek valley, shoreline areas of the Keta River, and in portions of the Tunnel Creek valley. Class 1 avalanches (sloughs and nuisance slides) are predicted in areas of Hill Creek, in some land areas along the Keta River, and some land areas adjacent to the Blossom River.

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 Freshwater Ecology

Important Aquatic Habitat and Fish Species

The rivers, lakes, and fjords in the project area provide spawning and rearing habitat for valuable stocks of salmon (pink, chum, chinook, coho, and sockeye), trout (steelhead/rainbow and cutthroat), and Dolly Varden char[1/]. Species of lesser importance that are found in this area include: threespine stickleback, sculpin, lamprey, and eulachon[1/]. Aquatic habitats within the project area include the Wilson and Blossom river systems, tributary to Wilson Arm of Smeaton Bay, and the Keta River system, tributary to Boca de Quadra.

Two smaller, but important, independent streams are Tunnel Creek and Aronitz Creek, which discharge into Wilson Arm and Boca de Quadra, respectively. Project area streams important to anadromous fish are shown in Figure 3-17.

Relative Production of Commercially Important Fish

The number of salmon returning to the Wilson, Blossom, and Keta rivers (i.e., escapement) has been inventoried annually since the late 1940s by the Alaska Department of Fish and Game (ADF&G) (Edgington and Larson 1977) and the U.S. Fish and Wildlife Service (USFWS) (Martin 1959). Surveys have also been conducted on Tunnel and Aronitz creeks since 1979 by U.S. Borax (VTN 1980b, 1981b, 1982c). Salmon escapement counts (peak escapement counts) were obtained during peak migration for most species. Peak escapement counts are not an estimate of total salmon escapement to a stream, and an escapement correction factor (see Appendix G, Table 2-1) has been applied to estimate the total escapement for each stream. The escapement of salmon has varied greatly over the past 30 years (Appendix G, Tables 2-2 to 2-4), primarily as a result of changes in management of commercial harvest. Recent management programs (last 12 years) have controlled salmon

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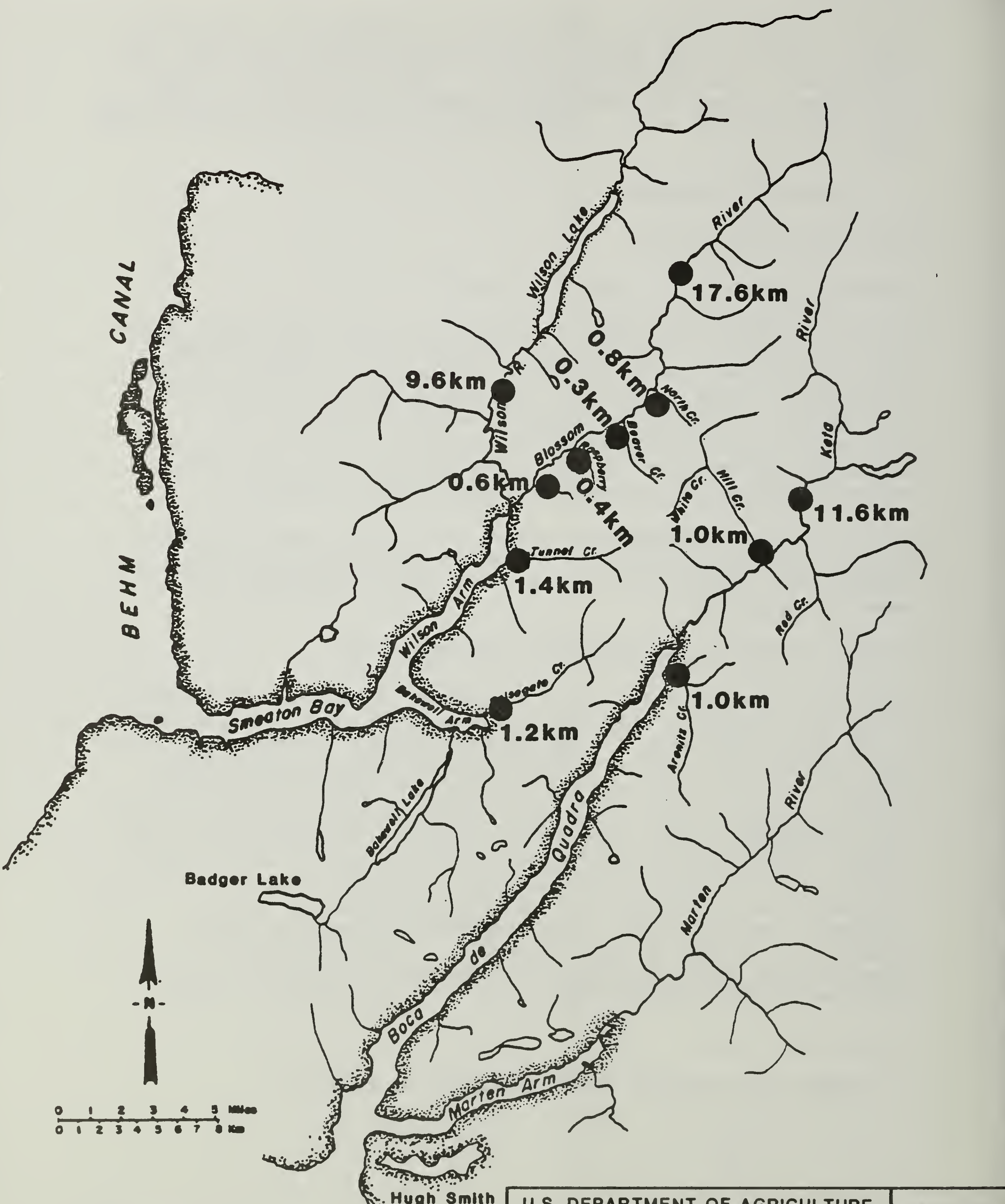
1/ Common and scientific names in Appendix G, Table 1-1.



LEGEND

● BARRIER TO FISH PASSAGE

km DISTANCE FROM STREAM MOUTH TO BARRIER

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PROJECT AREA RIVERS AND FJORDS

SOURCE ENVIROSPHERE DATE DEC 83

FIGURE 3-17

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harvest and enabled larger escapements to streams in the Quartz Hill area. Salmon escapements during the past 12 years are considered more indicative of a stream's productivity than the full record (IDT Meeting, Jan. 9-11, 1984, Ketchikan, AK). Therefore, statistics based on salmon escapements since 1974 are used in the following discussion of the affected environment and for the estimation of potential impacts due to the proposed project (Section 4.0).

A comparison of escapements for commercially important species (Table 3-9) indicates pink salmon are the most abundant species in the project area. The Wilson River has the largest population of pink salmon, even though its counts are inflated by spawner counts in the lower 0.5 mi (0.8 km) of the river that include some fish destined for the Blossom River. Collectively, the Wilson-Blossom system accounts for more than 80 percent of the average pink salmon escapement to the three major rivers. Pink salmon runs fluctuate on an odd-even year cycle, with the even year return considerably larger in the rivers (Appendix G, Tables 2-2 to 2-4). Chum, coho, and chinook salmon rank second, third, and fourth, respectively, in abundance in Quartz Hill area streams. Chum salmon are most abundant in the Keta and Blossom systems and consist of runs returning early (i.e., July-August) and late (i.e., September-October) in the year (VTN 1980b, 1981b, 1982c). The data base for coho salmon is very limited because the run timing coincides with the onset of poor weather in October and November when fish are difficult or impossible to count. Recent escapements of coho salmon are low as a result of high harvest rates, which average 80 percent (Gray 1983). Chinook salmon are the least abundant of the economically important salmon species, but are highly valued because of their contribution to the sport fishery. Chinook populations were declining prior to 1976 (Schmidt et al. 1977), but more recently have begun increasing as a result of greater control over commercial and sport fishing harvest (ADF&G 1979). Sockeye salmon, Dolly Varden char, steelhead trout, and cutthroat trout also spawn in the three major rivers; however, the numbers are small and reliable escapement data are unavailable. Salmon escapement data for Tunnel and Aronitz creeks are mostly limited to recent surveys for pink and chum salmon. Other smaller tributaries are utilized by small numbers of salmon, trout, and Dolly Varden char (Appendix G, Table 4-1).

Salmon production in the project area streams is relatively high compared to other streams in the vicinity. The Wilson, Blossom, and Keta rivers are within the ADF&G's District I statistical area, which contains 208 mi of streams utilized by anadromous fish (compiled from Edgington and Larsen 1977). Project area rivers represent 14 percent of the district total stream miles, and support 11-22 percent of the pink salmon, 19-32 percent of the chum salmon, and 19-47 percent of the chinook salmon escapements of District I (ADF&G 1979, Tables 2, 3, 4). The relatively high production of chinook salmon is noteworthy, as less

TABLE 3-9

ESTIMATED TOTAL SALMON ESCAPEMENT TO
STREAMS IN THE VICINITY OF THE QUARTZ HILL PROJECT

Stream	Estimated Total Escapement by Species1/			
	Pink	Chum	Coho	Chinook
Wilson River	388,302 2/ 128,000-660,000	3,594 50-21,406	1,050 1,050	244 14-600
Blossom River	135,280 15,200-594,000	6,556 200-16,006	2,985 1,455-4,050	482 108-1,178
Keta River	139,076 6,400-480,000	22,658 1,600-60,006	1,446 156-3,450	672 50-1,644
Tunnel Creek	8,434 2,800-19,900	576 400-1,200	... 3/ ...	... ...
Aronitz Creek	712 254-1,720	240 80-624	... ...	... ...

1/ Estimated total escapement equals peak escapement count (Appendix G, Tables 2-2 to 2-6) times an escapement correction factor (Appendix G, Table 2-1).

2/ Numbers are estimated mean and range for period 1974-1985.

3/ Estimates cannot be made because none or too few fish were counted.

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than 20 out of 2,000 streams in southeastern Alaska support chinook salmon runs (Schmidt et al. 1977); the majority are located in the Misty Fiords National Monument.

Important Commercial and Sport Fisheries

Salmon, trout, and Dolly Varden char produced in the project streams contribute significantly to commercial and sport fisheries in the Ketchikan area. An estimated average of 1,364,000 pink, 62,000 chum, 22,000 coho, and 5,600 chinook salmon produced in project streams are harvested annually by the commercial salmon fishery (Table 3-10). The average harvest of salmon from the project area represents 10 percent of the total catch from the Ketchikan area (Districts 1-4) during 1975 to 1985. Salmon produced in the Wilson River provide the largest proportion (5 percent) of the "regional" or "Ketchikan area" catch compared to the contributions from the Keta (2 percent) and Blossom (2 percent) rivers.

Sport fishing for salmonids originating in the project area is primarily limited to chinook salmon, coho salmon, and trout. Chinook and coho salmon are the most important sport fish in southeast Alaska. Total Ketchikan area sport catch is 3,991 to 5,415 chinook salmon (mean of 4,362) and 2,336 to 11,442 coho salmon (mean of 6,345) (Mills 1982). Approximately 80 to 108 chinook (mean of 87) and 35 to 172 coho (mean of 95) returning to the Quartz Hill streams are harvested annually by Ketchikan area sport fishermen. This represents 2 percent and 1.5 percent of the total Ketchikan area sport catch for chinook and coho, respectively (Seidelman 1983). Catch of other species is low as few sport fishermen travel into Smeaton Bay and Boca de Quadra, and almost none fish the rivers of the Quartz Hill area. Steelhead have been caught in the rivers and trophy size cutthroat have reportedly been caught from Wilson Lake (ADF&G 1980). However, accessibility currently limits fishing pressure.

As sport catches decrease in other areas due to restrictions on catch, limits, and seasons resulting from overfishing of stocks, the sport fishery for chinook salmon stocks returning to the Wilson, Blossom, and Keta rivers will increase in effort and importance as anglers shift to more distant, relatively unexploited stocks. Similarly, an increased sport fishery for chinook salmon will result in an increased catch of co-occurring species like coho salmon from project streams. Currently, pink and chum salmon could support a substantial sport fishery in local rivers and fjords, but are underutilized because the fishery in the Ketchikan area meets current demand (Schmidt et al. 1977).

Salmon Habitat Requirements and Habitat Availability in Quartz Hill Area Streams

Salmonids are present in project streams throughout the year. Their important life cycle events are illustrated in Figure 3-18. Adult salmon enter the streams in summer and spawn from August through

TABLE 3-10

ESTIMATED AVERAGE RETURN AND HARVEST OF SALMON PRODUCED IN STREAMS FROM THE QUARTZ HILL PROJECT AREA AND CONTRIBUTION TO AVERAGE COMMERCIAL HARVEST IN THE KETCHIKAN AREA (DISTRICTS 1-4)1/

	Number of Fish					
	Wilson River	Blossom River	Keta River	Tunnel Creek	Aronitz Creek	Total
Pink						
Estimated Average Return	1,176,672	409,939	421,442	25,557	2,157	2,035,767
Estimated Average Harvest2/	788,370	274,659	282,366	17,123	1,445	1,363,963
Percent of Average Area Harvest of Pink Salmon3/	5.81	2.02	2.08	0.13	0.01	10.05
Chum						
Estimated Average Return	10,268	18,731	64,737	1,645	686	96,067
Estimated Average Harvest4/	6,674	12,175	42,079	1,069	445	62,442
Percent of Average Area Harvest of Chum Salmon	1.11	2.02	6.98	0.18	0.07	10.36
Coho						
Estimated Average Return	5,250	14,925	7,230	166 6/	16 6/	27,587
Estimated Average Harvest5/	4,200	11,940	5,784	133	13	22,070
Percent of Average Area Harvest of Coho Salmon	0.88	2.50	1.21	0.03	<0.01	4.63
Chinook						
Estimated Average Return	1,220	2,410	3,360	29 6/	1 6/	7,020
Estimated Average Harvest7/	976	1,928	2,688	23	1	5,616
Percent of Average Area Harvest of Chinook Salmon	1.34	2.64	3.68	0.03	0	7.69
All Salmon						
Estimated Average Return	1,193,410	446,005	496,769	27,397	2,860	2,166,441
Estimated Average Harvest	800,220	300,702	332,917	18,348	1,904	1,454,091
Percent of Average Area Harvest of All Salmon	5.44	2.04	2.26	0.12	0.01	9.88

1/ Computations based on data from Table 3-9 and methods used by ADF&G (1979, page 9).
2/ Pink salmon harvest is estimated to average 67 percent of total adult return (ADF&G 1979, Table 9).
3/ Calculated as a proportion of the average Ketchikan area harvest (Appendix G, Table 3-1).
4/ Chum salmon harvest is estimated to average 65 percent of total adult return (mean of 79 percent and 50 percent from ADF&G 1979, Table 12).
5/ Coho salmon harvest is estimated to average 80 percent of total adult return (Gray 1983).
6/ From Appendix G, Table 4-1.
7/ Chinook salmon harvest is estimated to average 80 percent of total adult return (Kissner 1983).

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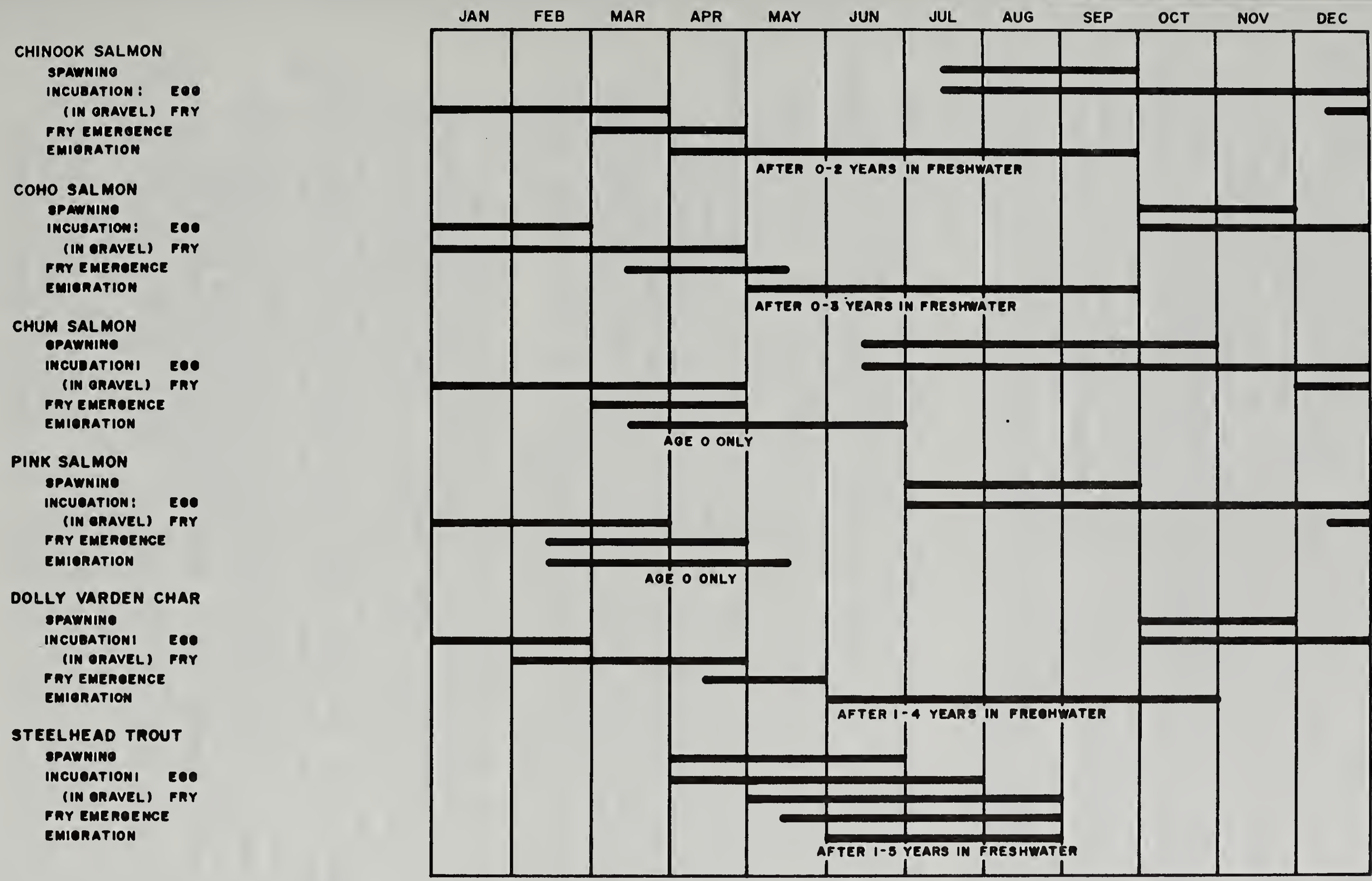

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TIMING OF LIFE HISTORY EVENTS FOR SALMONIDS IN QUARTZ HILL AREA STREAMS

SOURCE VTN 1983g | DATE DEC 83

FIGURE 3-18

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November. Spawners require unobstructed access to spawning areas and an adequate supply of gravel with relatively low sediment content. The optimum gravel size for spawning by pink, chum, and chinook salmon is 1.3-10.2 cm (Bell 1973). Incubation of eggs and alevins (fry with yolk sac attached) in the gravel occurs from autumn through spring. Incubation is a critical phase in the salmon life history because excessive sediment (particles smaller than 4 mm must not exceed 30 percent, ADEC 1982) in the gravel can retard embryonic development during incubation or prevent emergence of newly hatched fry. After emergence from the gravel, pink and chum salmon fry rear in streams for only a short time before migrating into the estuary on their seaward migration. Chinook salmon, coho salmon, rainbow trout, Dolly Varden char, and cutthroat trout rear in fresh water from one to five years, depending upon species. Juveniles rearing in streams are highly vulnerable to habitat impacts because they require good water quality, adequate streamflows, and sufficient cover (e.g., logs, undercut banks, and overhanging vegetation).

Estimates of available spawning habitat in the Wilson, Blossom, and Keta rivers are 83,165 m^2, 79,759 m^2, and 71,755 m^2, respectively (VTN 1982d). However, the length of each river accessible to spawners and the distribution of spawning habitat varies between rivers (Table 3-11). Spawning habitat in the Blossom River is distributed over a much greater length of river (10.9 mi) than in the Wilson (6.0 mi) and Keta (7.2 mi) rivers. The utilization of spawning habitat by adult spawners is not similar to the distribution of spawning habitat in most cases (Table 3-11). Pink and chum salmon tend to concentrate in the middle and lower reaches of the three major rivers, with some deviation between years. Chinook and especially coho spawn largely in the middle and upper reaches, including small tributaries. Annual changes in the distribution of spawners are due largely to the changes in spawner density from year to year.

Spawning gravels in the project streams currently contain low concentrations of sediment and are of sufficient quality to provide high survival for incubating salmon embryos. Concentrations of fine particles (<4.0 mm diameter) ranged from 2.6 to 19.8 percent in the Wilson River, from 0.6 to 30.3 percent in the Blossom River, and from 0.0 to 29.4 percent in the Keta River (VTN 1982d, p. 2-3) during April and August 1982. Concentrations of fines are considerably lower in the Wilson River because Wilson Lake functions as a sediment trap. The Blossom River has a higher concentration of fines than the Keta River as the lower portion of the river is dominated by pools and the substrate is predominantly sand. Mean concentrations of fines are less than 16 percent for the three major rivers and less than 11 percent for Raspberry and Tunnel creeks (VTN 1982d, p. 2-3). During construction of the bulk access road, a landslide into No. 1 creek caused concentrations of fines in spawning gravels of the Blossom River to exceed 22 percent (Appendix G, Figure 6-1). However, the effects of the slide were temporary and conditions returned to ambient levels within one year.

TABLE 3-11

DISTRIBUTION OF SALMON SPAWNING HABITAT RELATIVE TO PEAK SPAWNING DISTRIBUTION OF PINK, CHUM, CHINOOK, AND COHO SALMON IN THE WILSON, BLOSSOM, AND KETA RIVERS DURING 1981 AND 1982[1/]

River Reach	Spawning Habitat (percent)		Salmon Spawning in Reach (percent)						
			Pink		Chum		Chinook		Coho
	in Reach	Cumulative	1981	1982	1981	1982	1981	1982	1981
Wilson River									
Km 0.0 - Km 0.8[2/]	6	6	3	9	0	0	0	0	0
Km 0.8 - Km 4.8	51 [3/]	57	82	85	62	23	10	0	0
Km 4.8 - 9.6	43	100	15	6	38	77	90	100	100
Blossom River									
Km 0.0 - Km 5.2	25	25	25	30	24	18	0	0	0
Km 5.2 - Km 8.7[4/]	22	47	13	12	0	1	0	20	0
Km 8.7 - 11.9	22	69	29	24	38	78	56	26	10
Km 11.9 - Km 17.6	31	100	33	34	38	3	44	54	90
Keta River									
Km 0.0 - Km 4.0	52	52	41	68	42	42	30	16	0
Km 4.0 - Km 6.9[5/]	22	74	9	6	47	32	26	23	10
Km 6.9 - Km 11.6	26	100	50	26	11	26	44	61	90

1/ Information compiled from VTN (1981b, 1982c, 1982d).
2/ Includes section below confluence with Blossom River; 1 km equals approximately 0.62 mi.
3/ Spawning habitat inventoried in reach ending at Km 4.0.
4/ Section ends at confluence with Beaver Creek. Reaches above this point are not susceptible to project influence.
5/ Section ends at confluence with Hill Creek. Reaches above this point are not susceptible to project influence.

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The distribution of juvenile salmonids rearing in project streams is species specific and changes with time of year. Juvenile pink and chum salmon rear for a short time after emergence in early spring near adult spawning areas. Fry prefer the main river channel and major side channels in shallow, slack water along the margins of riffles and in glide areas with a cobble/gravel substrate (VTN 1980b, 1981b, p. 13). Juvenile chinook and coho salmon inhabit all stream areas, but are most abundant near cover in slack water or pools, especially beaver ponds and sloughs. Dolly Varden char juveniles prefer mainstem bank areas, side channels, and tributaries. Juvenile Dolly Varden char, chinook salmon, and coho salmon move into the side channels and tributaries during the summer and return to the mainstream during the fall, where they remain throughout the winter (Elliott 1980). The total rearing habitat for juvenile salmon in the Wilson, Blossom, and Keta rivers has been estimated from aerial photographs as follows (VTN 1983g):

	Wilson River		Blossom River		Keta River	
	Acres	Hectares	Acres	Hectares	Acres	Hectares
Main and Side Channels	44.4	18	61.7	25	37.0	15
Ponds	14.8	6	17.3	7	12.3	5
Estuary	345.7	140	..	..	197.5	80
TOTAL	404.9	164	79.0	32	246.8	100

The availability of summer and winter habitats and suitable access to these habitats is critical to the survival and production of salmonids in the project streams. Based on these criteria, the ADF&G subjectively rated the Blossom River as having the best rearing potential, the Keta River second, and the Wilson River as third (Schmidt et al. 1977) in the project area.

Aquatic Habitat Potentially Affected By Changes In Instream Flow

Blossom River:

The proposed supplemental water supply intake will be located near the mouth of the Blossom River, just upstream of its confluence with the Wilson River. The intake will be a filtration bed in the streambed that collects intergravel flow.

Salmonids utilize this area primarily for upstream and downstream passage. Very little salmonid spawning occurs downstream of the site (see Table 3-11).

According to calculations by U.S. Borax (Reim 1987), it appears that sufficient flows would be available to maintain adequate conditions for fish passage. It is estimated that river discharge at the pumping station would be greater than approximately 300 cfs during a "wet year" for most of the period of upstream passage, with minimum flows still

greater than about 100 cfs for most of the low flow periods in winter. Although occasional decreases to about 60 cfs might occur during the low flow period, no fish would be expected to be migrating through this area at that time.

During a "dry year," discharge would remain above 200-300 cfs during periods of downstream or upstream migration. During the low flow winter season, the flow at the mouth could be as low as 10-20 cfs during water withdrawal periods. Again, because this is typically a nonmigratory period for either juveniles or adults, it is expected that there would be no impact to migratory salmonids.

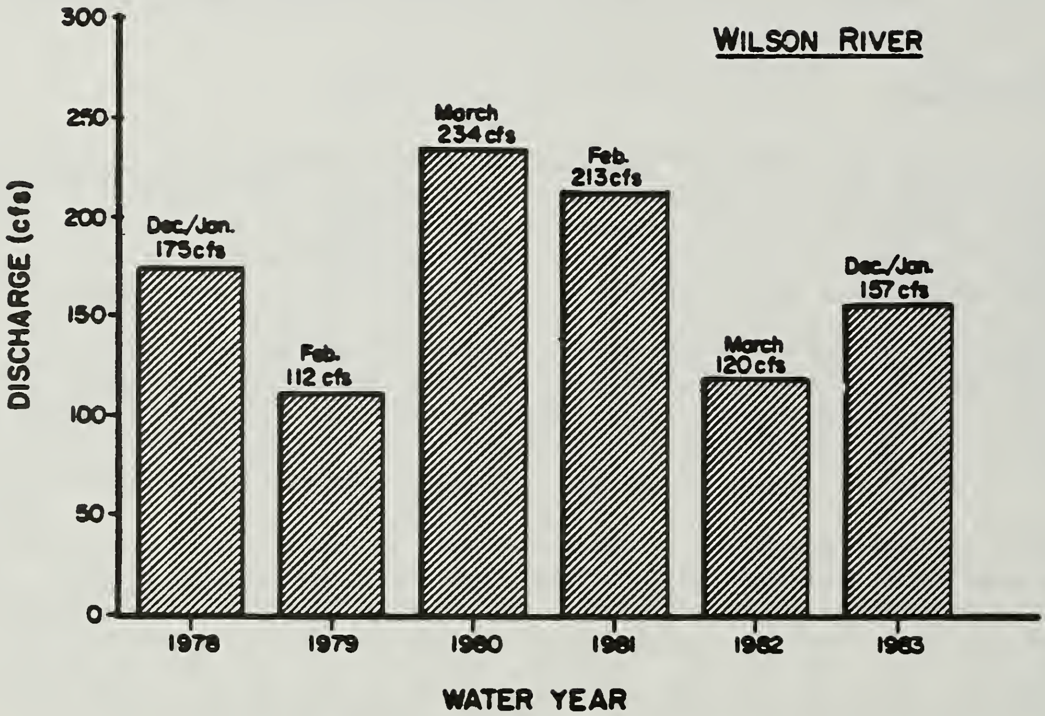
Any potential effects on fish passage would also be negated by flows in the Wilson River (which can back up into the intake area on the Blossom) or tidal influence, which periodically ($\pm$ 6 hr cycle) slows the outflow of the Blossom and Wilson rivers.

Wilson River:

Results from the instream flow study (Lyons and Nadeau 1985) conducted in the Wilson River and Tunnel Creek indicate that the availability of habitat during the winter incubation period when the lowest flows of the year occur is a primary factor limiting salmon production. Salmon redds that remain wetted during the incubation period are assumed to be viable; whereas, redds that are located above the winter low-flow channel are assumed to experience 100 percent mortality. Thus, the amount of viable habitat available for fish production (termed Effective Weighted Usable Area [EWUA]) is defined by the area located between the portion of the stream subjected to scouring and that portion which is dewatered by the lowest 7-day average low-flow event.

Hydrologic data developed by Bechtel Civil and Minerals, Inc. (1983c), indicated that streamflows in the Wilson River during the winter incubation period (lowest winter 7-day average low-flow events) ranged from 112 cubic feet per second (cfs) to 234 cfs for a 6-year period (Figure 3-19). The average incubation flow was about 175 cfs. The spawning flow that provided the greatest effective habitat (EWUA) for pink salmon incubation flows of 100 cfs through 225 cfs was 770 cfs (Figure 3-20). For incubation flows of 100 cfs and 175 cfs the optimum spawning flow decreases to 670 cfs. The flow exceeds 770 cfs 66 percent of the time during the spawning season (Figure 3-21).

The spawning habitat availability peaks with flows near 2,000 cfs with a habitat area of 56,000 ft^2/1,000 ft of stream length for pink salmon (Figure 3-22). Spawning flows greater than 770 cfs provide favorable conditions for spawning activities higher on the gravel bars, but the salmon redds will become dewatered at lower flows. Lyons and Nadeau (1985) concluded that the maximum spawning-incubation habitat for pink salmon was 32,220 ft^2/1,000 ft, resulting from a spawning flow of 770 cfs succeeded by an incubation flow of 225 cfs. With these flow conditions, a total of 340,200 ft^2 of effective habitat was realized.



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOWEST 7-DAY LOW-FLOW EVENT IN
THE WILSON RIVER, ALASKA.
Synthetic Data October 1977 through March 1983

SOURCE (Bechtel 1983). DATE

FIGURE 3-19

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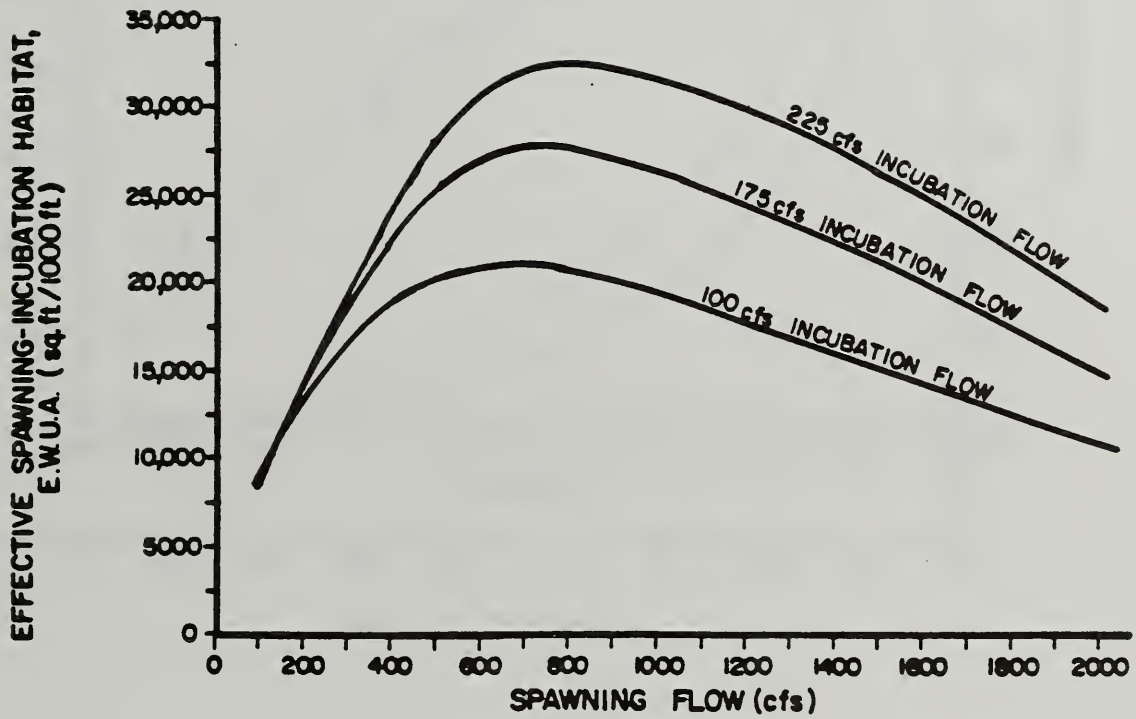

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MINE DEVELOPMENT EIS

WILSON RIVER PINK SALMON
SPAWNING-INCUBATION HABITAT, E.W.U.A.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-20

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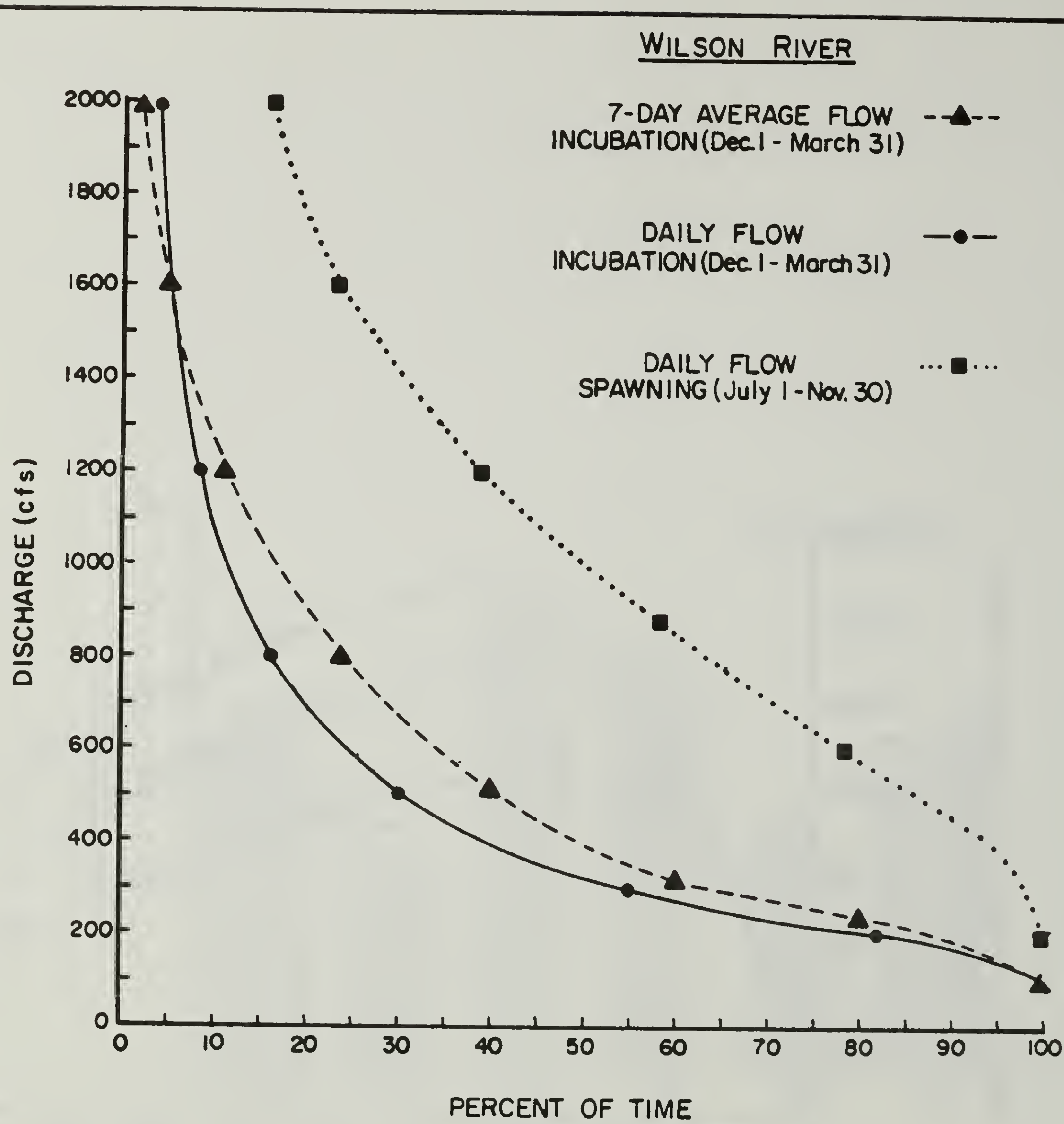

U.S. DEPARTMENT OF AGRICULTURE
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MINE DEVELOPMENT EIS

PERCENT OF TIME A FLOW IS EQUALED OR EXCEEDED FOR THE WILSON RIVER SITE.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-21

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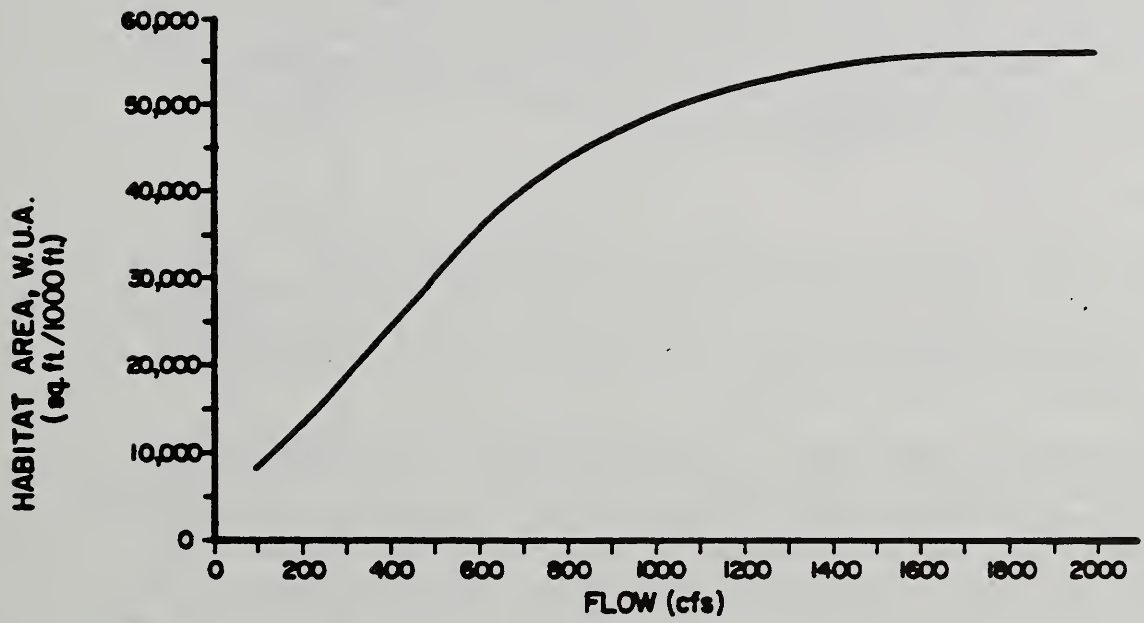

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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

WILSON RIVER PINK SALMON SPAWNING
HABITAT AREA, W.U.A.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE
3-22

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Chinook, coho, and chum salmon do not use the area below the proposed well field for spawning (VTN 1982f, 1983g). These adults only require flows adequate for passage. During the upstream migration period, flows exceed 400 cfs 94 percent of the time, providing passage (Figure 3-21).

Chinook and coho salmon also require habitat in the affected area of the Wilson River for rearing. Juvenile coho salmon rearing habitat peaked at about 250 cfs, while that of the juvenile chinook salmon peaked at between 100 cfs to 200 cfs (Figures 3-23 and 3-24). Both chinook and coho fry (1 yr) utilize habitat of lower velocity, as reflected by the peaks in this habitat occurring at 50 cfs. However, habitat peaks at the lowest flows do not accurately depict optimal flows for rearing because these flows are lower than those that naturally occur on the Wilson River.

Tunnel Creek:

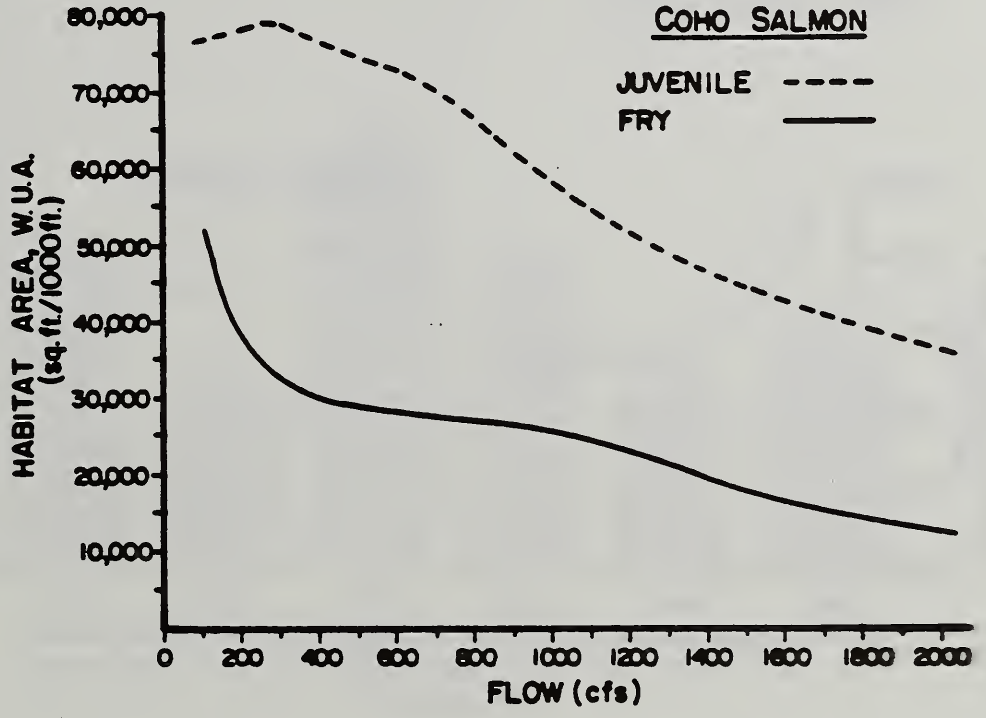
Three stream segments were analyzed within Tunnel Creek. The first site, upper Tunnel Creek, was located above the fork and represented 0.6 mi of available stream. The other two sites were located within the tidally influenced area at the mouth of each of the two forks and represented 0.15 mi of stream.

Tunnel Creek - Upper Reach: For the 6 years of hydrologic data developed by Bechtel Civil and Minerals, Inc. (1983c), the incubation flow events (lowest 7-day average low-flow) ranged from 7 cfs to 22 cfs (Figure 3-25), with a median of 11 cfs for the upper Tunnel Creek site. The median flow during the spawning season was 90 cfs. The three species that spawned in the affected areas of Tunnel Creek were pink, chum, and coho salmon. Spawning flows that provided the greatest habitat ranged from 100 cfs to 250 cfs, depending upon the salmon species (Figure 3-26).

The spawning-incubation habitat for pink salmon achieved from the average spawning flow of 90 cfs, succeeded by an incubation flow of 15 cfs, was 7,500 ft^2/1,000 ft of stream length (Figure 3-27) or a total of about 23,800 ft^2 of effective habitat. The incubation flow of 15 cfs was equalled or exceeded about 80 percent of the time during the incubation period (Figure 3-28).

Chum salmon spawning-incubation habitat was 10,300 ft^2/1,000 ft of stream, resulting from the median spawning flow of 90 cfs, succeeded by an incubation flow of 15 cfs (Figure 3-29). This represented a total of 32,600 ft^2 of habitat in upper Tunnel Creek. This was not the maximum habitat but was the best that could be expected under the natural flow conditions that occur in the Tunnel Creek drainage.

The spawning-incubation habitat for coho salmon was 6,000 ft^2/1,000 ft or a total represented area of 19,000 ft^2 (Figure 3-30). This resulted from a median spawning flow of 90 cfs, followed by an incubation flow of 15 cfs. This was not the maximum habitat but the habitat resulting from naturally occurring flow events.



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FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

WILSON RIVER COHO SALMON REARING
HABITAT AREA, W.U.A.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-23

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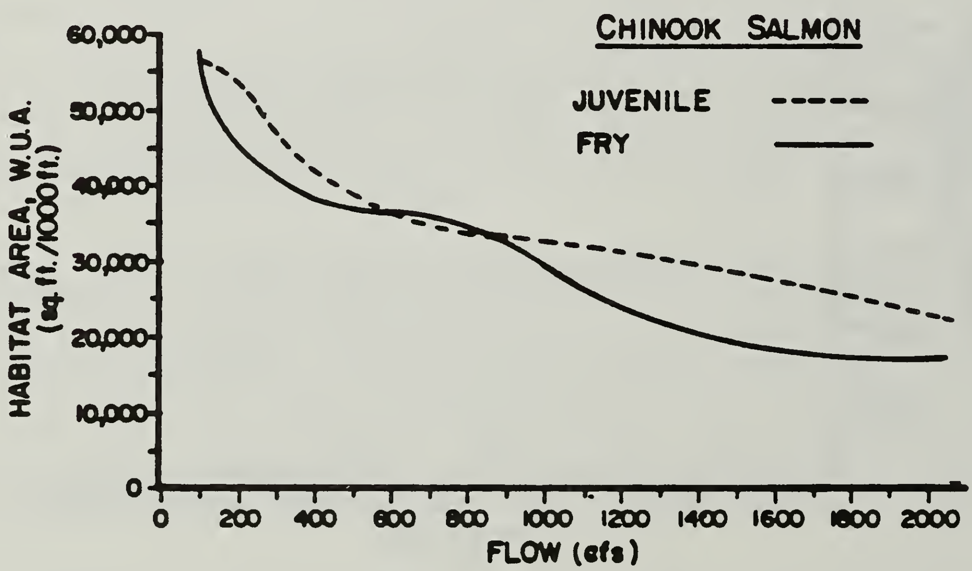

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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

FIGURE 3-24

WILSON RIVER CHINOOK SALMON REARING
HABITAT AREA, W.U.A.

envirosphere company
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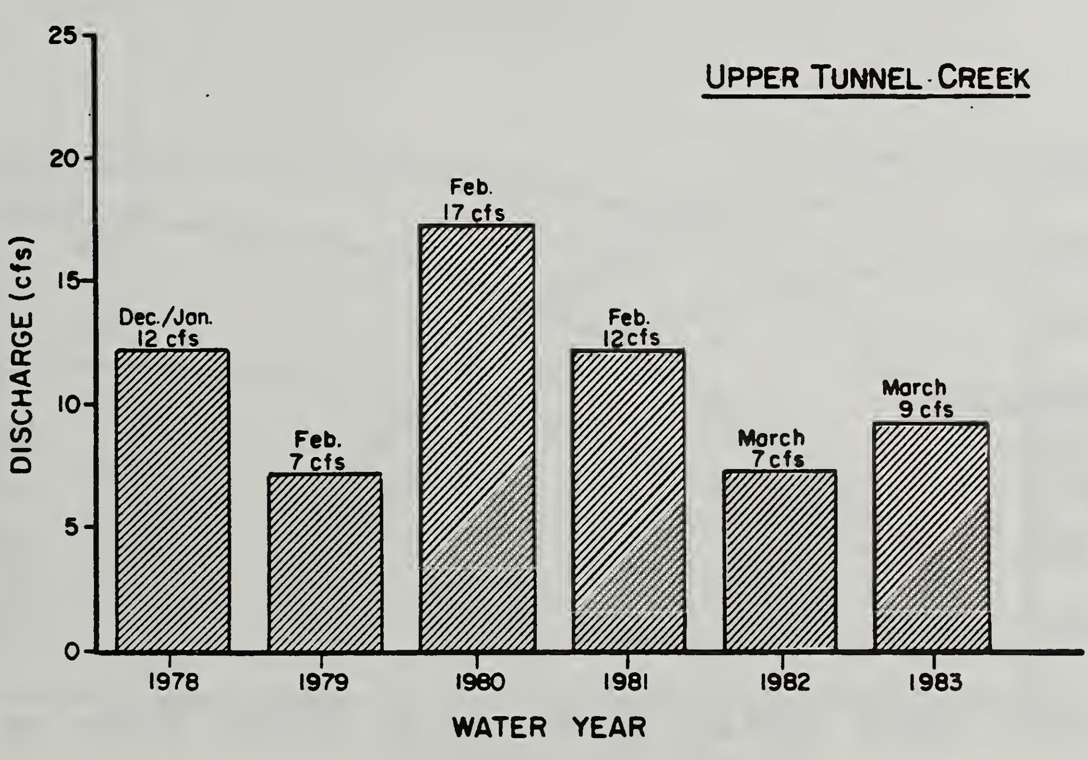
SOURCE LYONS and NADEAU (1985) DATE



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

LOWEST 7-DAY LOW-FLOW EVENT IN THE UPPER TUNNEL CREEK, ALASKA.
Synthetic Data October 1977 through March 1983

SOURCE (Bechtel 1983) DATE

FIGURE 3-25

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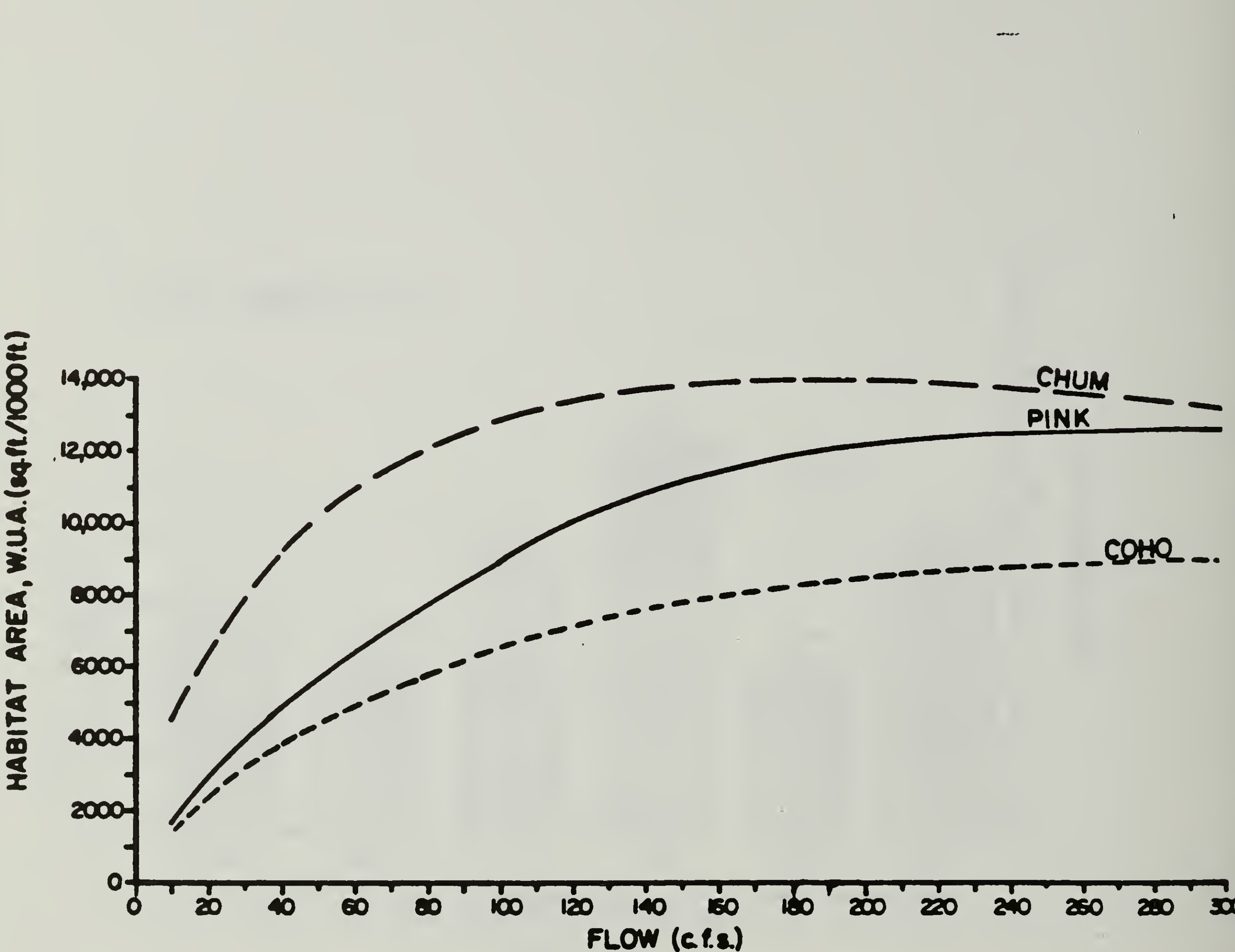
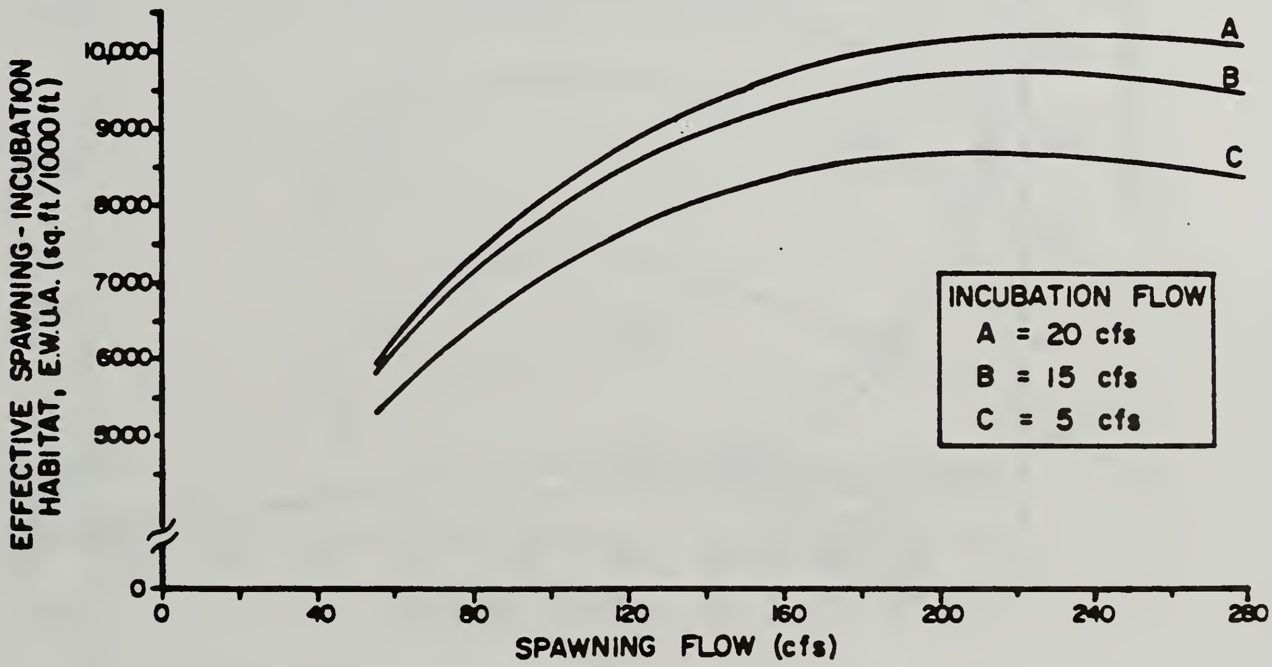


U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-26
UPPER TUNNEL CREEK SPAWNING HABITAT AREA, W.U.A.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE LYONS and NADEAU (1985) DATE	



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FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

UPPER TUNNEL CREEK PINK SALMON SPAWNING - INCUBATION HABITAT, E.W.U.A.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-27

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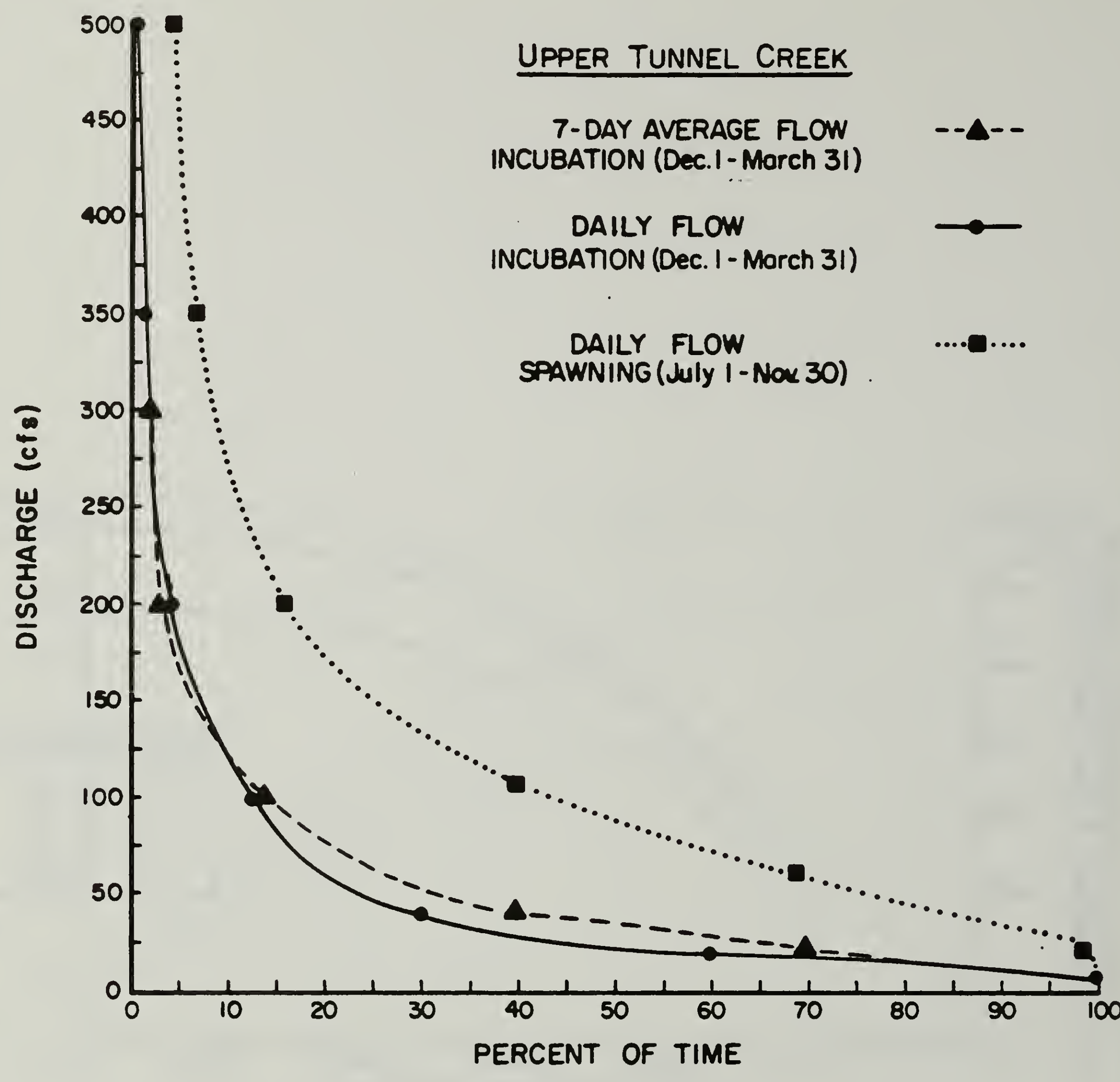

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FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

PERCENT OF TIME A FLOW IS EQUALLED OR EXCEEDED FOR THE UPPER TUNNEL CREEK SITE.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-28

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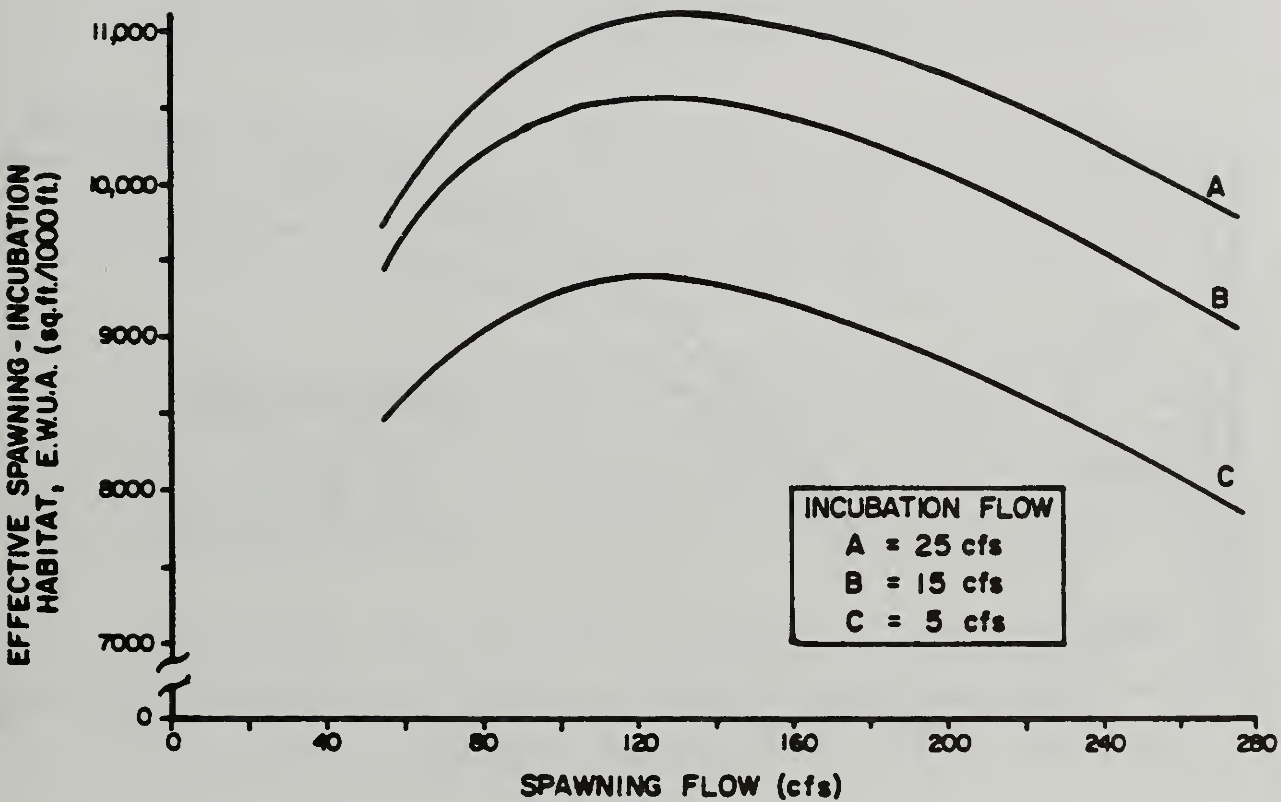
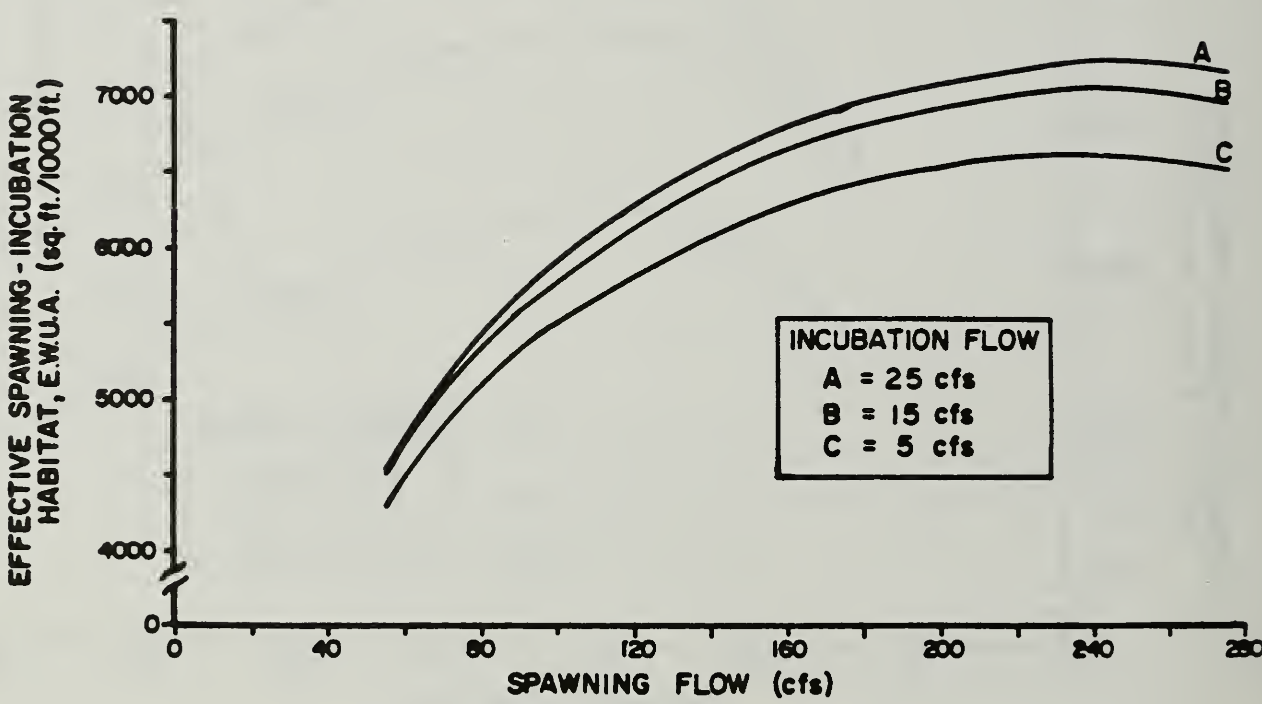


U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-29
UPPER TUNNEL CREEK CHUM SALMON SPAWNING HABITAT, E.W.U.A.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE LYONS and NADEAU (1985) DATE	



U.S. DEPARTMENT OF AGRICULTURE
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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

UPPER TUNNEL CREEK COHO SALMON SPAWNING HABITAT, E.W.U.A.

SOURCE LYONS and NADEAU (1985) DATE

FIGURE 3-30

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Tunnel Creek has numerous debris piles, root balls, large scour pools, undercut banks, and back eddies for rearing coho salmon. With increased flow, more of the available areas become usable by fry and juvenile coho. As flows continue to increase to higher flow levels, flow velocities become limiting and rearing habitat decreases. At the upper Tunnel Creek site, rearing habitat for fry and juvenile coho salmon peaks with discharges of 30 cfs and 75 cfs, respectively.

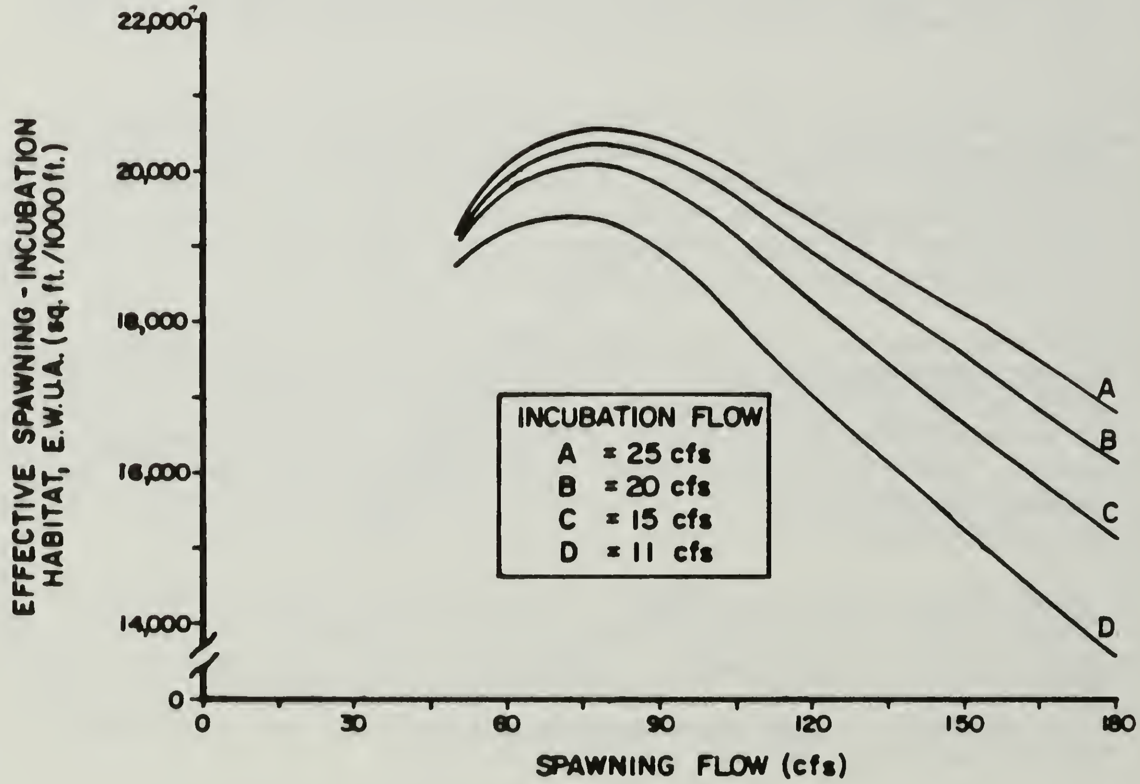
Tunnel Creek - Lower Right Reach: The lower right Tunnel Creek site was located within the intertidal delta area. At this location the effect of daily tides appeared to bias the results of the study, resulting in larger effective habitat with significantly lower streamflows. Although pink salmon will spawn in brackish water, the incubating eggs require a certain amount of fresh water to survive. Only chum salmon and pink salmon were observed using this intertidal area.

The greatest pink salmon spawning-incubation habitat occurred with a spawning flow of 75 cfs, followed by an incubation flow of 25 cfs (Figure 3-31). This provides 20,500 ft^2/1,000 ft of viable habitat or a total of 16,300 ft^2. There was very little change in viable habitat with a decrease in incubation flow down to 11 cfs. At 11 cfs the spawning-incubation habitat was 19,400 ft^2/1,000 ft.

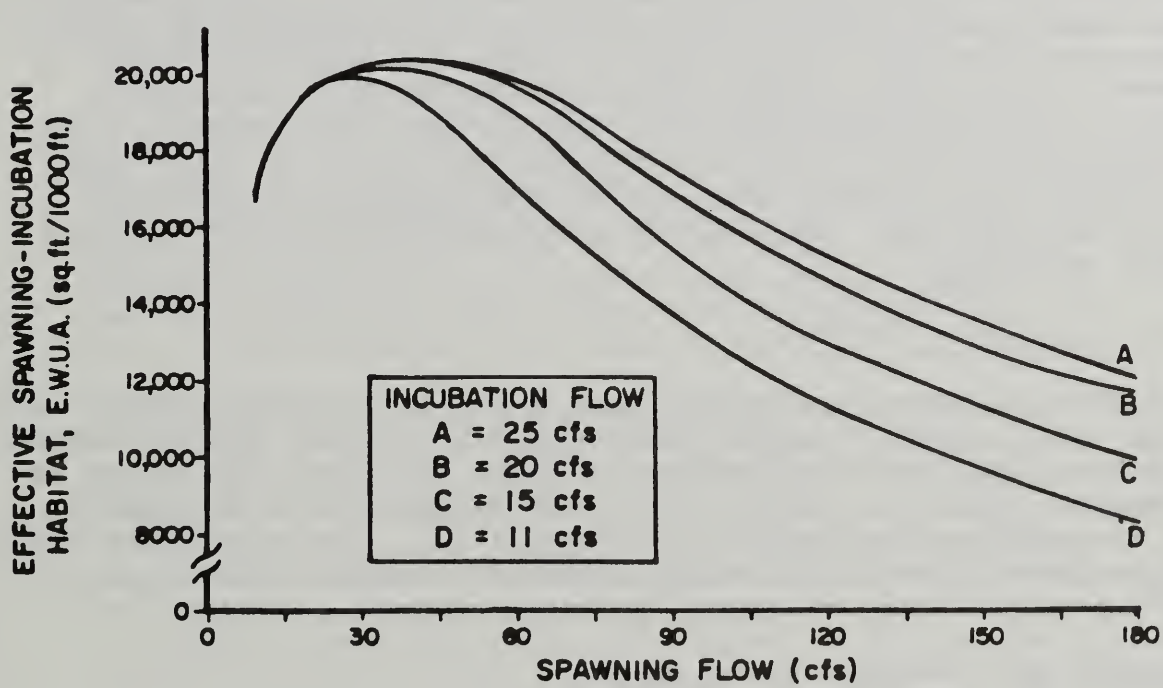
Potential chum salmon habitat was similar to that of pink salmon. For the chum salmon the greatest spawning-incubation habitat of 20,300 ft^2/1,000 ft was obtained with a spawning flow of 50 cfs, succeeded by an incubation flow of 25 cfs (Figure 3-32). As with pink salmon habitat, there was little change in habitat with a decrease in the incubation flow to 11 cfs. In this case, the habitat decreased to 19,800 ft^2/1,000 ft.

Tunnel Creek - Lower Left Reach: At present the lower left site of Tunnel Creek is only an overflow channel. At lower flows this channel does not have any discharge. In the very recent past this site appears to have carried the main flow, with the right channel acting as the flood channel. In any year the flow changes from the right channel to the left channel, and back again.

Spawning-incubation habitat was calculated for the lower left Tunnel Creek site. Results were similar to those of the lower right channel site, with a slightly lower potential habitat. However, there is no fresh water flow during much of the incubation period, so no successful reproduction is expected to occur. From the available data, if the main flow should shift back to the lower left site, the viable habitat would be about 85 percent of that of the lower right channel.



U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-31
LOWER RIGHT TUNNEL CREEK PINK SALMON SPAWNING - INCUBATION HABITAT, E.W.U.A.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE LYONS and NADEAU (1985) DATE	



U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 3-32
LOWER RIGHT TUNNEL CREEK CHUM SALMON SPAWNING- INCUBATION HABITAT, E.W.U.A.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE LYONS and NADEAU (1985) DATE	

3.2.2 Marine Ecology

This section discusses items pertinent to the ocean discharge criteria described in 40 CFR 125.122. Items specifically discussed include composition of the biological communities, food chains, spawning and nursery areas, migration pathways, areas important to critical life cycle stages of organisms, and the existing and potential recreational and commercial fishery.

Marine Habitat Types

As defined in the Quartz Hill Project Environmental Report (U.S. Borax 1983a, pp. 7-61 to 7-73), Boca de Quadra and Wilson Arm/Smeaton Bay have five general categories of marine habitats: (1) the epipelagic or open water photic region (≤ 100 ft deep); (2) the mesopelagic or open water below the photic zone (>100 ft deep) to within 30 ft of the bottom; (3) the deep benthic habitat, which is >100 ft deep and includes the bottom and the water to 30 ft above the bottom; (4) the nearshore habitat or the area within 300 ft of shore to 100 ft deep, including the intertidal zone; and (5) the estuary or region where fresh and salt water interact with a bottom of fine-grained alluvial river sediments.

Unique Species or Habitat

Currently no unique species have been identified in either Smeaton Bay/Wilson Arm or Boca de Quadra. The major habitat types are also common within the many fjords of southeast Alaska. The one exception may be estuaries. Within a limited range, only about 2,000 ac of estuaries are present (see Section 4.2.3 and Table 4-15). The largest one within this region is the Wilson estuary (320 ac). Although these estuaries are not unique, their abundance is fairly restricted.

Salmonid Use of Project Marine Waters

Juvenile salmonids in Quartz Hill streams utilize the estuaries and fjords of Wilson Arm, Bakewell Arm, and Boca de Quadra for rearing prior to entering open ocean. Pink and chum salmon were most abundant in 1982 in Wilson Arm, whereas in Boca de Quadra and Bakewell Arm chum and sockeye salmon were most abundant (VTN 1982e, p. 30). The use of estuaries by juvenile salmonids is a function of numerous abiotic and biotic factors (Iwamoto and Salo 1977; Simenstad et al. 1982). Pink and chum salmon fry (average fork length 35 and 40 mm, respectively) migrate to the estuary within days after gravel emergence. Timing of emergence and outmigration is largely dependent on water temperature during egg incubation. Therefore, outmigration usually occurs from March through June and peaks during April. This generally corresponds to other estuaries along the Pacific coast (Simenstad et al. 1982). Estuarine residence time ranges from three to five weeks for pink salmon and one week to two months for chum salmon (VTN 1981c, 1982e). Residence times for chum salmon are similar to those of Washington State (Simenstad et al. 1982). Coho and chinook salmon juveniles remain in fresh water for one or more years before migrating to the estuary; peak use of the estuary for these species was June and July

(compiled from VTN 1982g). Coho reside in the estuary for two to three weeks, chinook for between one and three months, before moving into deeper, offshore areas. Sockeye salmon juveniles, Dolly Varden char, and steelhead trout also utilize the estuaries, but no information is available on residence time for these species.

The spatial distribution and abundance of juvenile salmonids in the estuaries vary according to species and size. Pink salmon are most abundant along the lower edge of the mud/sand flats and rare in the salt marsh channels of the inner estuary; chum salmon are found within all habitat types. Chum salmon may move to pelagic habitats as they increase in size (Simenstad et al. 1982). Young-of-the-year coho are found almost exclusively in salt marsh channels, while age one and older coho are found in deeper water areas. Chinook are abundant in salt marsh channels and cobble beach areas (VTN 1982e). Tidal marsh channels are also utilized by chinook rearing in other estuaries, such as the Fraser River estuary (Levy and Northcote 1982). The abundance of juvenile salmonids (all species) in Wilson Arm was highest in the nearshore area along the west shoreline from a bight near the mouth of the Wilson River downfjord 0.8 mi to a small creek in a cove, and along the east shoreline from north of the float dock to a small point at the beginning of the Tunnel Creek delta (VTN 1982e, Figure 3-12). In Boca de Quadra the abundance of juvenile salmonids was highest along the west shoreline from a small bight at the mouth of the Keta River to a point 1,800 ft downfjord (VTN 1982e, p. 52).

The diets of juvenile pink and chum salmon consist of invertebrates and fish common to Wilson Arm and Boca de Quadra. However, only a few prey species provide the greatest portion of the diet and the dominant prey species differ between fjords and time of year. As found elsewhere along the Pacific coast (Healey 1979; Simenstad et al. 1982), harpacticoid copepods were the predominant diet in late March and April in both fjords. In May, juvenile pink and chum salmon diets in Wilson Arm shifted to subadult euphausiids, whereas in Boca de Quadra diets shifted to barnacle larvae. Pink salmon also consumed large numbers of calanoid copepods from March through April, while chum salmon consumed insects (midges and stoneflies) during June. Calanoid copepods often become more important to fish with increase in size and movement into offshore habitats (Simenstad et al. 1982). In general, the diets of juvenile pink and chum salmon can vary with time depending upon the density, size, and availability of prey species, habitat, fish size, time of day, and environmental conditions (Iwamoto and Salo 1977; Simenstad et al. 1982; VTN 1982e). Although the food habits of chinook and coho salmon were not examined in the project area, their diets likely consist of gammarid amphipods, euphausiids, decapod (shrimp) larvae, insects, and small fish (Dunford 1975; Healey 1980; Simenstad et al. 1982).

Predation has been suggested as a principal cause of estuarine and marine mortality of juvenile Pacific salmon (Parker 1971). In Boca de Quadra and Wilson Arm/Smeaton Bay, adult salmonids, Pacific herring, Pacific staghorn sculpin, spiny dogfish, walleye pollock, whales, dolphins, porpoises, and fish-eating birds co-occur with, and may prey on, juvenile Pacific salmon (Parker 1971; Dunford 1975; Armstrong 1970;

Simenstad et al. 1979; Jones and Geen 1977). Because potential predators were not examined in baseline studies, it is not possible to define the magnitude and scope of predation in the fjords.

Important Marine (Nonsalmonid) Fish

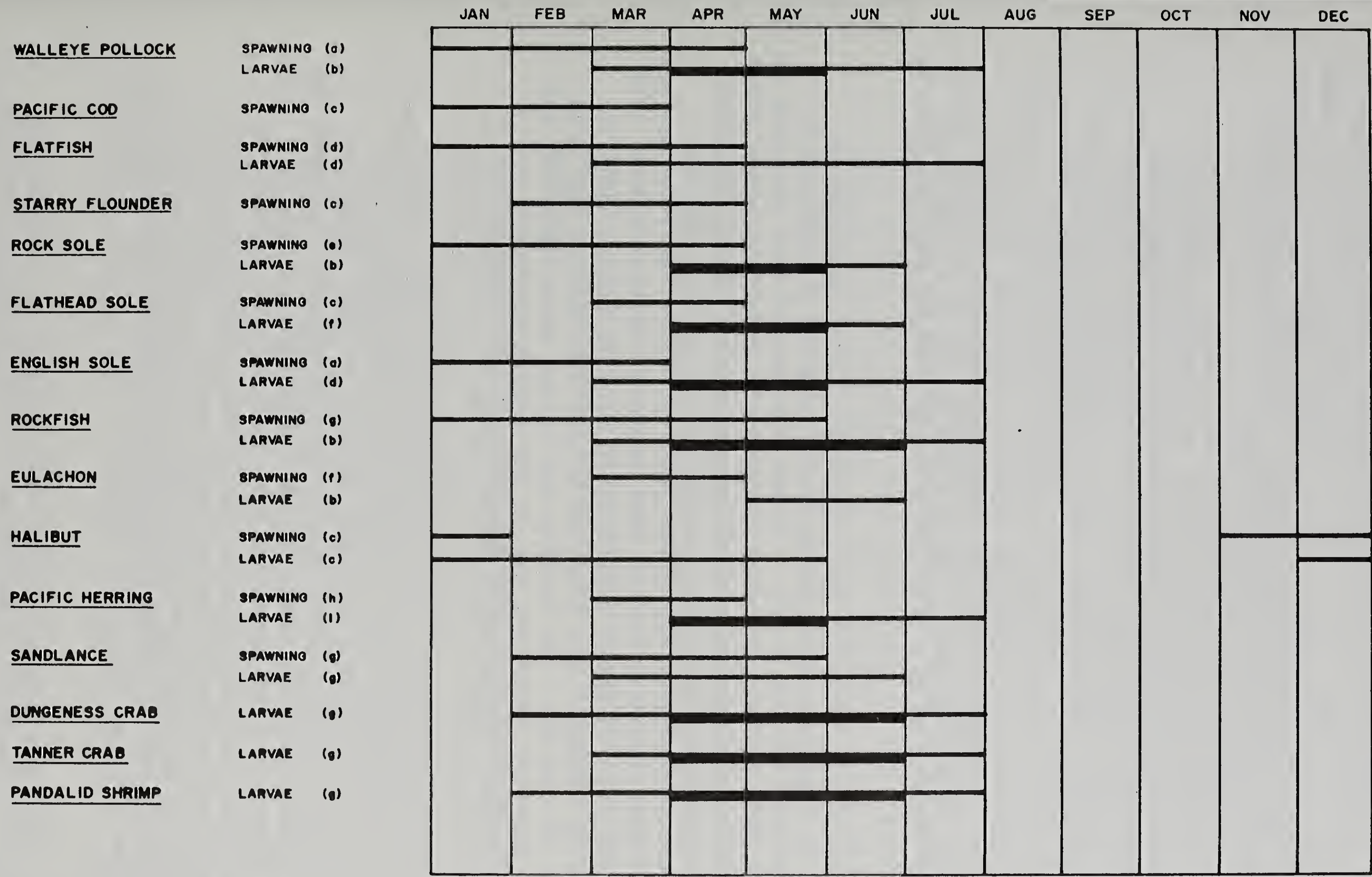
Important marine (nonsalmonid) fish species that occur in Boca de Quadra and Wilson Arm/Smeaton Bay include walleye pollock, Pacific cod, Pacific halibut, English sole, Pacific herring, darkblotched rockfish, quillback rockfish, yelloweye rockfish, Pacific sandlance, black cod, and eulachon. These species are recognized as economically or ecologically important in southeast Alaska and are abundant in Boca de Quadra or Wilson Arm/Smeaton Bay. Other marine fish that were either found in significant quantities during sampling or may be of ecological importance include other rockfish, flatfish, sharks, eelpouts, pricklebacks, and sculpins. Species lists of fish present in Boca de Quadra and Wilson Arm/Smeaton Bay can be found in VTN reports (VTN 1980c, p. 89, 1981d, p. 80, 1982f, p. 33, 1982f, pp. 43 and 109).

Abundance, Life Histories, and Habitat Importance:

The following paragraphs discuss, by major family, abundance, life histories, and distribution of important marine (nonsalmonid) fish. Because of differences in sampling gear, depths, and number of samples between years and seasons, it was not possible to accurately assess differences in abundance between basins, bays, and fjords in more than a qualitative nature.

Flatfish - Flatfish (Pleuronectidae) are one of the most common and diverse fishes in the fjords. Common species include rocksole, flathead sole, English sole, slender sole (VTN 1983h, p. 115), and halibut. Much of the following discussion is based on catch of these species by otter trawl. Otter trawl catch data in the various documents for the region were presented as catch per unit effort, with effort being distance (km) the trawls were towed, and not bottom area sampled (km^2). Flatfish were one of two most abundant groups captured by otter trawl in both fjords in 1981. They were more abundant in the inner basin (0.7382 kg/km) of Boca de Quadra than the middle basin (0.1107 kg/km) and also more abundant in Wilson Arm (5.9553 kg/km) than Bakewell Arm (1.5279 kg/km) or Smeaton Bay (0 kg/km) in 1981 (U.S. Borax 1983a, pp. 7-124 and 125). Halibut were caught by long line sampling in Bakewell Arm and Smeaton Bay in October 1981 (VTN 1983h, p. 116); none were caught in Wilson Arm and no long lining was conducted in Boca de Quadra.

Larval flatfish rear mainly in the epipelagic and possibly mesopelagic (open water) zones. Highest abundance occurs from April through early June (Figure 3-33; VTN 1982h, pp. 12 and 33). Flatfish larvae were the fourth most abundant larvae captured in both fjords (VTN 1982h, pp. 12 and 33); the most abundant were rock, flathead, and English sole. Sampling results suggested that flathead and English sole spawn inside the fjords (VTN 1983h, p. 115) in winter and early spring. Depth distribution of larvae was not measured because sampling was conducted only in the upper 80 ft of the water column (VTN 1982h, p. 7). After



NOTES:

(a) ROGERS ET. AL. 1980 HEAVY LINE INDICATES PEAK PERIOD OF SPAWNING AND LARVAL ABUNDANCE FOR THESE AREAS.
(b) OBSERVED IN BOCA DE QUADRA OR SMEATON BAY/WILSON ARM.
(c) HART 1973
(d) BASED ON INFORMATION ON ALL ROCK SOLE , ENGLISH SOLE , FLATHEAD SOLE.
(e) DUNN ET. AL. 1980
(f) VTN 1982j
(g) BASED ON LARVAE CATCH.
(h) BLANKENBECKLER AND LARSON 1982a.
(i) VTN 1982i

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CRITICAL LIFE STAGES OF MARINE FISH AND SHELLFISH IN SMEATON BAY / WILSON ARM AND BOCA DE QUADRA

SOURCE ENVIROSPHERE DATE DEC 83

FIGURE 3-33

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the pelagic stage, flatfish larvae settle to the bottom. Juvenile stages of English sole are found in the intertidal or nearshore shallow areas. Although some seasonal depth movement may occur, as flatfish grow they move deeper (Hart 1973, p. 628; International Pacific Halibut Commission [IPHC] 1978, pp. 7-11). The flathead sole, which was common in trawls as juveniles (VTN 1983d, p. 115) settle directly into deeper benthic areas. The lack of juvenile halibut in trawls suggests that few young halibut are present in these fjords.

Flatfish larvae are thought to feed mainly on calanoid copepods (Simenstad et al. 1979, p. 22), but may also feed on diatoms and flagellate algae (VTN 1983h, Figure 5.3-2). VTN suggests juvenile and adult flatfish in the fjords feed on gammarid amphipods and isopods when near shore and on marine worms, crangonid shrimp, amphipods, clams, pandalid shrimp, and eelpouts in deeper benthic areas. Halibut feed mainly on tanner crab, dungeness crab, and pandalid shrimp (VTN 1983h, Figure 5.3-4, and 5.3-6). The magnitude of importance of each food item to each species has not been evaluated in these areas, but a generalized description of the food webs for each major habitat type is discussed later.

Codfish - Cod (Gadidae) were the most abundant fishes captured in trawls in Boca de Quadra's inner basin (1.0724 kg/km) in 1981 (U.S. Borax 1983a, Tables 7-22 and 7-23). It was the second most abundant in Bakewell Arm (0.3580 kg/km), but less frequent or absent in other areas during 1981. The majority of the catch was walleye pollock. Pacific cod were rarely captured in trawls, and infrequently in long line samples in Wilson Arm/Smeaton Bay (VTN 1981d, p. 114). Walleye pollock were the second most abundant larval fish captured in both fjords (VTN 1982h, pp. 12 and 33). Highest densities in Boca de Quadra were in Marten Arm, and in Bakewell Arm from the Wilson Arm/Smeaton Bay area (VTN 1982h, pp. 15 and 38). No Pacific cod larvae were captured, but their eggs are demersal (near but not in the bottom surface), so occurrences in surface trawls would normally be rare (Rogers et al. 1983, p. 49).

Larval catch data indicate walleye pollock spawn outside of the fjords and larvae drift into these areas. Larvae are more abundant in subsurface than surface waters in other parts of Alaska (Rogers et al. 1983, p. 52). During 1982, juveniles were captured near the shoreline but were not present in these areas in 1981 (VTN 1983h, p. 117). Trawl data indicate juveniles were common at the shallow head end of the fjords. Larger fish and adults were less common (VTN 1983h, p. 117). Spawning probably occurs in winter and early spring (Figure 3-33). Juveniles settle to the bottom. Walleye pollock are found in pelagic habitats in other areas of Alaska (Feder 1979). Adults were typically abundant in other Alaskan regions at depths of 300-1,200 ft (Rogers et al. 1983, p. 52).

Larval fish in the early pelagic stage feed directly on diatoms and flagellate algae and later on zooplankton. Juvenile walleye pollock fed heavily on euphausiids and calanoid copepods (VTN 1982h, pp. 30 and

52-53). Larger juveniles consumed euphausiids. The smaller juveniles (age 0) consumed mostly calanoid copepods. Larger fish feed on shrimp, sandlance, Pacific herring, young salmon, mysids, euphausiids, and capelin (VTN 1980c, p. 127).

Rockfish - Rockfish (Scorpaenidae) comprised less than 2 percent of all fish in trawl catches and were only captured in the inner basin of Boca de Quadra and in Wilson Arm during 1981 (U.S. Borax 1983a, pp. 7-124 and 125). Catches were also low during other years, with few adults captured (VTN 1983c, p. 117). Darkblotched rockfish juveniles were the most frequently captured species. Adults were mainly quillback and yelloweye rockfish captured on hook and line, and occasionally in shrimp pots (VTN 1983c, p. 117). Yelloweye rockfish are rarely taken in trawls (Hart 1973, p. 442). During 1981, quillback rockfish were collected in a depth range of 88-220 ft (VTN 1981d, p. 131).

Rockfish were the third most abundant fish larvae captured in Boca de Quadra and Wilson Arm/Smeaton Bay (VTN 1982h, pp. 12 and 33). Rockfish larvae are common in surface waters (Rogers et al. 1983, p. 57). Because these fish are live bearers, captured young were most likely born within the fjord. Peak occurrence in both fjords was during May (Figure 3-33) (VTN 1982h, p. 61). Rockfish diets were not examined extensively by VTN, but according to Feder (1979), nearshore rockfish feed heavily on fish, starfish, crab, and shrimp.

Pacific Herring - Herring (Clupeidae) were the most abundant fish captured in nearshore habitats in Boca de Quadra and third most abundant in Wilson Arm/Smeaton Bay (VTN 1982g, pp. 64 and 131). Large concentrations of herring, mostly young-of-the-year and some age 1^+, were observed throughout Boca de Quadra and its sidearms during the summer. This did not occur in Wilson Arm/Smeaton Bay (VTN 1982i, pp. 48-51). Only a small number of age 2^+ fish and older were captured in both bays.

Herring were rarely present in otter trawl catches because of their pelagic habits. The only quantitative study of herring abundance, other than larvae, in these fjords was conducted in February 1980 (Street 1980), which estimated over a million herring in the pelagic water at the head of Boca de Quadra. The exact depth of distribution was not stated, but the midwater trawl used sampled a 50 ft depth (Minicucci 1983). The study found herring in all bays of Boca de Quadra. Herring started to appear in scattered patches about 7 mi from the head end in the main fjord and became more concentrated upfjord. Abundance was uniform in the entire inner basin. Fish were nearly all one year old and most likely had overwintered in Boca de Quadra.

Large concentrations of herring spawn outside the mouth of Boca de Quadra at Kah Shakes and vicinity during late winter and early spring

(VTN 1982i, p. 49). There is no indication of major spawning near the mouth of Wilson Arm/Smeaton Bay. No major spawning occurs in either fjord. Minor spawning occurs in the inner basin of Boca de Quadra. Larval herring were generally the most abundant larval fish found in the fjords (VTN 1982i, 1982h). Peak density was about the same in the outer basins of Boca de Quadra and the mouth of Smeaton Bay/Wilson Arm (17,000-18,000 fish/1,000 m^3). Mid-Smeaton Bay, sidebays of Boca de Quadra, and outer middle basin of Boca de Quadra had similar peak densities (2,000-3,000 fish/1,000 m^3). The inner portion of the middle basin and inner basin of Boca de Quadra had the lowest densities (100-800 fish/1,000 m^3). Wilson Arm/Smeaton Bay had reduced numbers farther in the bay (VTN 1982i, pp. 18 and 34). Most larvae in both fjords probably originated from spawning fish at the mouth of Boca de Quadra. Some larvae found in the low density areas of Boca de Quadra originated from spawning in the inner basin (VTN 1982i, p. 52).

Herring school as juveniles and adults (Taylor 1964). In Alaskan and British Columbian stocks, juveniles are often found in nearshore areas through their first summer of life and typically move offshore in autumn (Reid 1972; Taylor 1964). These fish are usually not seen again until they enter the spawning population (Taylor 1964). The behavior of herring in the fjords apparently is different than that found in other areas. Large numbers of age 0 and 1+ fish were found near Mink Bay and Vixen Bay during mid-October 1982. Large numbers of juveniles were also observed in the inner basin of Boca de Quadra in February 1982. Presence at these times indicates overwintering in these areas (VTN 1982i, p. 50). Some fish also overwinter in Wilson Arm/Smeaton Bay but probably at lower abundance than in Boca de Quadra (VTN 1982i, p. 51).

Three and four age classes (age 0 to age 3) of herring were present in Wilson Arm/Smeaton Bay and Boca de Quadra, respectively. Only age 0 abundance was determined during regular studies; winter night trawl sampling in Boca de Quadra indicated the majority were one year old. Larval sampling was done only in the upper 80 ft; therefore, depth distribution could not be determined. Carlson (1980) found adult herring near Auke Bay, Alaska spent most of the summer in the upper 16-121 ft, but spent the winter at 171-279 ft. This movement to deeper areas was apparently to avoid light levels sufficient for visual predation (Carlson 1980, p. 76). If the area were shallower than their preference depths, the schools would flatten out along the bottom, while in deeper areas they would remain in the pelagic zone (Carlson 1980, p. 76).

The major diet of herring sampled in both fjords was calanoid copepods (61 percent, Index of Relative Importance [IRI]), followed by limicina (11 percent), and harpactacoid copepods (10 percent IRI). Generally, calanoid copepods were the major food item of young-of-the-year (96 percent IRI) and one year olds (66 percent IRI). For older fish (those >12 cm), major food items were euphausiid adults (43 percent IRI), fish eggs (27 percent IRI), and harpacticoid copepods (18 percent IRI) (VTN 1982i, pp. 56-61). Calanoid copepods are typical food for pelagic

herring, while those near shore rely more on harpacticoid copepods (Simenstad et al. 1979, p. 85). Very little feeding apparently occurred after September. Fasting during the winter is typical for Pacific herring (Carlson 1980, p. 76).

Smelt - Eulachon (Osmeridae) were the most abundant of the smelt family captured in the two fjords. Adult smelt were the least abundant of the fish families captured in trawls in Boca de Quadra, but consisted of 2 percent of the catch in trawls in Wilson Arm. They were 14 percent of the total catch in Smeaton Bay in March 1982 (VTN 1982h, pp. 11 and 34). An estimated run of 30,000 eulachon occurred during March in the Wilson/Blossom rivers. No runs were observed in the Keta River (VTN 1982h, p. 58).

Eulachon captured in trawls were adults probably returning to the Blossom and Wilson rivers to spawn. Larval abundance in the fjords was very low; it was highest in the head ends of both fjords from April to June. Distribution of juvenile and adults are probably epi- and mesopelagic as they are taken in midwater trawls (Hart 1973, p. 149). Young feed mainly on copepods, phytoplankton, mysids, ostracods, barnacle larvae, cladocera, and worm larvae (Hart 1973, p. 149). Apparently these fish are an important food source for sea lions in Wilson Arm/Smeaton Bay as 15-20 sea lions were observed in the area during the eulachon spawning run.

Pricklebacks - During 1981, pricklebacks (Stichaeidae) were the second most abundant group captured in trawls in the Boca de Quadra inner basin (1.0275 kg/km) and the third most abundant in the Boca de Quadra middle basin (0.0591 kg/km) (U.S. Borax 1983a, pp. 7-124 and 7-125). Abundance was low in Wilson Arm but high in Smeaton Bay (0.1027 kg/km). The longsnout prickleback was common in otter trawls in both fjords (VTN 1983h, p. 118). Longsnout pricklebacks have been found at moderate depths (300-390 ft) in British Columbia (Hart 1973, p. 335). Longsnout pricklebacks feed on a variety of items, including foraminiferans, clams, harpacticoids, and cumaceans in the deep benthic environment (VTN 1983h, p. 157).

Eelpouts - Eelpouts (Zoarcidae) were low in abundance in the Boca de Quadra inner basin (0.1072 kg/km) and absent from the middle basin during 1981 (U.S. Borax 1983a, p. 7-124, 7-125). They were the second most abundant fish captured in Wilson Arm (2.9672 kg/km) in 1982, with much lower abundance in Smeaton Bay (0.0213 kg/km). Blackbelly and shortfin eelpouts were common in trawls in the heads of both fjords. The blackbelly eelpout is common in muddy bottoms at depths of 60-720 ft in British Columbia, while the shortfin eelpout was found to a depth of 2,100 ft (Hart 1973, pp. 242 and 246). Spawning occurs in fall and winter. Their main food was bivalve mollusks in British Columbia (Hart 1973, p. 246). Eelpouts in these fjords were found to feed on a variety of items in the deep benthic environment including marine

worms, brittle stars, clams, amphipods, copepods, and euphausiids (VTN 1983h, p. 157).

Effects of Environmental Conditions:

Two key factors affecting survival and growth of marine fish in project marine waters are food availability and predation. For example, increased growth of walleye pollock in Boca de Quadra from early May to early June coincided with an increase in their food supply (VTN 1982h, p. 63). Sandlance and herring are both preyed upon by fish and birds (Simenstad et al. 1979, p. 21) and both species are often found in the shallow nearshore area of both fjords. Juvenile eulachon are eaten by juvenile chum salmon in Wilson Arm, whereas adults are prey items for marine mammals (VTN 1982h, p. 58). Eggs of spawning flatfish and cod are consumed by herring in early spring (VTN 1982i, p. 31).

In addition to predator-prey relationships, water quality can influence marine organisms. The water quality of the upper 250 ft of both bays during the spring and summer is not currently hazardous to the present fish populations, although oxygen levels near bottom may at times be stressful (3 mg/l) (VTN 1982g, Appendix A). Low temperatures (about 43-46°F) in the early spring result in slow growth of most marine fish (Hoar et al. 1979). Also, the freshwater lenses that are typically in the upper 7 ft may restrict feeding by marine fish, especially during June when the depth of the lens is greatest.

Sport and Commercial Harvest of Marine Fish:

Presently, there is no substantial sport or commercial harvest of marine fish in the two fjords. Some beam trawl fishing has occurred for codfish, flatfish, and rockfish (House 1983a). Some marine fish that are harvested in areas adjacent to Boca de Quadra or Wilson Arm/Smeaton Bay probably will utilize the two fjords for spawning or rearing. The most important of these is a commercial herring roe fishery totalling over a million dollars annually occurring at the mouth of Boca de Quadra at Kah Shakes. No direct herring fishing has been reported in the bays (Blankenbeckler and Larson 1982a, pp. 5 and 11, 1982b, p. 7). Herring larvae and juveniles, common in both Boca de Quadra and Smeaton Bay, may ultimately constitute a significant portion of the adults harvested in the herring roe fishery. Additionally, major halibut fishing grounds occur near Duke Island west of, but not within, the two fjords (IPHC 1978, p. 6).

Marine Invertebrates

Economically Important Epibenthic Invertebrates:

Dungeness Crab - Both juvenile and adult dungeness crab prefer the shallow depths of these fjords. Crab pot catches indicate crabs were about 2-6 times more abundant in the upper 300 ft than between 300 and

620 ft, and rarely found below 620 ft (VTN 1982g, pp. 61 and 129, 1982f, p. 51, 1981d, p. 108; Hoopes 1973). Dungeness crab dominated VTN tanner crab pot catches (nearly 100 percent) in areas <300 ft deep and comprised 20-45 percent of the catch at intermediate depths. Juvenile dungeness crabs were often found in the eelgrass, particularly in Wilson estuary (VTN 1983h, p. 101). Dungeness crabs were captured in trawls mostly in the shallow portion of inner Boca de Quadra and Wilson Arm. Abundance was very low, except for shallow areas at the head end of Boca de Quadra. Abundance at similar depths in middle Boca de Quadra and Smeaton Bay was not determined by trawls because comparable depths were along steep shorelines where trawling was not possible.

In Boca de Quadra, greatest abundance of dungeness crab larvae occurred in areas other than the middle basin (VTN 1982k, pp. 51-52). Distribution and abundance of larvae was more uniform in Wilson Arm/ Smeaton Bay (VTN 1982i, pp. 17 and 38). Larvae were most abundant in the euphotic zone (<100 ft) where they feed. Spawning apparently occurs within Boca de Quadra and may occur in Wilson Arm/Smeaton Bay (VTN 1982j, pp. 52-53). Larvae were present during all months of sampling from February to July, with peak periods of abundance between April and June (Figure 3-31). Peak mean density of 2,000-3,000/1,000 m^3 occurred in both fjords (VTN 1982j, pp. 12 and 34).

Dungeness crab larvae are pelagic for the first 3-4 months of life before they settle to the bottom and become demersal (Hoopes 1973). Day and night depth distribution of larvae was not determined in these fjords, but studies near Yakutat found 70 percent in the 10-30 m range during the day and greater than 50 percent between 50-90 m at night (Rogers et al. 1983, p. 76). These crabs become mature in 2 years (females) to 3 years (males) in these basins. Adults of commercial size (males >165 mm) were common in the crab pot catches (VTN 1981d, p. 136, 1980c, p. 130).

Pelagic larvae may be partially herbivorous as the initial peak abundance coincides with phytoplankton blooms in April followed by rapid growth (VTN 1982j, p. 50). They may also feed on crustacean nauplii (Simenstad et al. 1979, p. 21). As they mature and settle into the deep benthic habitat, they feed on clams, marine worms, amphipods, and detritus (VTN 1983h, p. 157).

Tanner Crab - Tanner crab were collected in trawls, tanner crab pots, and shrimp pots in both fjords. Few large adult crabs (>100 mm carapace width) were found in depths less than 330 ft; they were most abundant in the 300 to 620 ft depth range and least abundant in the deepest areas such as the outer part of the Boca de Quadra middle basin. Tanner crab were present in nearly all trawls sampled, with catch rates similar in both fjords. Higher trawl catch rates were found in the Boca de Quadra inner basin than the outer basin (VTN 1983h, p. 118).

Larval tanner crabs apparently originated from crabs residing within these fjords (VTN 1982j, p. 52). Peak average density occurred in April through June (Figure 3-33) with 221 and 1,030/1,000 m^3 in Boca de Quadra and Wilson Arm/Smeaton Bay, respectively. No distinctive distribution trends were observed in either fjord. Newly hatched larvae may be herbivorous, feeding on algae. As they grow they feed on zooplankton. Paul et al. (1979) found that zooplankton density played a major role in early survival of tanner crab larvae.

The depth distribution of larvae was not studied in these fjords. However, near Yakutat, 98 percent occurred at a depth of 33-165 ft during the day and 74 percent were at a depth of 165-295 ft at night (Rogers et al. 1983, p. 80). As larvae develop they tend to move deeper in the water column (Ito and Ikehara 1971). When larvae settle to the bottom they initially cover themselves with debris and begin to feed on detritus (Rogers et al. 1983, p. 81). Full size adults (>100 mm carapace) develop within these fjords, but commercial size crabs >140 mm were rarely captured.

Donaldson (1980, pp. 50-51) found that adult tanner crab around Kodiak Island moved from bays to offshore areas with an average distance traveled of 15 mi. Rarely did crabs travel long distances. Other studies of tanner crabs suggest that migration is mostly limited to spawning activities, with movement from deeper to shallower areas in the spring (Feder et al. 1981, p. 167).

Feder (1981, pp. 177-181) stated that the diet of the same genus of crab are similar throughout their range. While diet is somewhat dependent on organisms present, organisms are not eaten in direct proportion to abundance. Major food items include brittle starfish, young crabs of the same species, clams, polychaetes, other crustaceans, detritus, and fish. Rogers et al. (1983, p. 81) states the genus *Chionoecetes* feed largely on ophiuroids, decapods, amphipods, and bivalves. Stomachs sampled in these fjords contained only detritus.

Pandalid Shrimp - This group contains all commercially harvested shrimp species of Alaska. The most abundant members in project area fjords are the spot, coonstripe, pink, and sidestripe shrimp. Spot and coonstripe were most abundant at depths less than 490 ft but were also common below this depth (VTN 1981d, pp. 131-133, 1980d, pp. 133 and 138). These two species were most abundant along the sides of the fjord in shrimp pot catches in areas inaccessible to trawls (VTN 1983h, p. 120).

Spot shrimp occurred in more than 50 percent of all trawls in the Boca de Quadra inner basin and Wilson Arm, but were infrequent or absent from trawls in Bakewell Arm, Smeaton Bay, and the Boca de Quadra middle basin. Their catch was probably a function of depth distribution, as they were most common in shrimp pots in Boca de Quadra in the 330-460 ft depth range.

Coonstripe shrimp occurred in 63 percent of all trawls in Wilson Arm/ Smeaton Bay. They were common in trawls in the Boca de Quadra inner basin, but were absent from the middle basin trawls. This is also probably a function of the shallower depth preferred (VTN 1981d, pp. 131-134, 1980c, pp. 133-134).

Butler (1980) reported that sidestripe shrimp are typically more abundant in depths greater than 240 ft and pink shrimp in the 160 ft to 300 ft range. Sidestripe shrimp occurred in nearly 100 percent of all trawls in both fjords. Pink shrimp were collected in greater than 85 percent of all trawls in both fjords (VTN 1981d, pp. 131-136, 1980c, pp. 131-139).

Pandalid shrimp larvae, which includes many species, were present in catches during all sampling months (February-July), with peak abundance occurring from April through June (Figure 3-33). Peak mean larval density was 738 and 1,280/1000 m^3 in Boca de Quadra and Wilson Arm/ Smeaton Bay, respectively. No statistical horizontal differences in abundance were found within the fjords. The general appearance of larvae in all areas at about the same time in both fjords suggests that these shrimp probably spawn within the fjords (VTN 1982j, pp. 51-52).

Density of all decapod larvae was higher in the upper 80 ft than 80-330 ft depth (VTN 1980c, p. 68). If patterns of pandalid shrimp larvae are similar to crab larvae, they would spend considerable time during the day in the mesopelagic zone (>100 ft deep) as well as the epipelagic zone. As these larvae develop they will settle to the bottom and commence a mainly demersal existence. Pandalid shrimp in these fjords generally feed on marine worms, clams, copepods, and detritus (VTN 1983h, p. 157). Studies of feeding habits of pandalid shrimp in Cook Inlet found that pink shrimp feed mainly on crustaceans, polychaetes, and diatoms, and in the water column on zooplankton. Coonstripe shrimp fed on crustaceans, polychaetes, and bivalves. Sediment and unidentified organic matter accounted for up to 60 percent of coonstripe shrimp stomach contents (Feder et al. 1981, p. 181).

Abundant Benthic Organisms:

Within both fjords the rocky intertidal area (nearshore and estuary) was dominated by mussels and barnacles along the rockwall, and within the interstitial spaces midges were often present. In the rocky subtidal (nearshore and estuary) areas, sea stars, brachiopods, and tunicates were the most characteristic on steep walls, and *Pycnopodia* on gradual slopes. The soft bottom intertidal, which was found mainly in the river deltas and heads of bays, had three characteristic regions. Insects (e.g., midges) were found at the higher tide elevations where *Carex* appeared. Isopods and amphipods were common in the *Fucus* zones, *Macoma baltica*, polychaetes, and harpaticoid copepods were found in the sand/mud regions. The soft bottom subtidal areas were characterized by varying species of polychaetes and other marine worms. The specific composition was similar in both fjords for similar depths (VTN 1983h, p. 60).

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Zooplankton:

Both fjords have nearly identical zooplankton populations, including species composition, abundance, and annual cycles. Although horizontal patterns in abundance were observed within the fjords, these changes were a continuum, as opposed to discrete populations, and the patterns were not consistent in their horizontal changes. The only significant horizontal break in patterns in either fjord occurred at the Kite Island sill in Boca de Quadra.

Increased zooplankton abundance and biomass (ash free dry weight) increases were tied to the annual spring diatom blooms in both fjords. Ash free dry weight peaked between May and July every year and zooplankton abundance peaked after the start of the spring algal blooms. Lowest zooplankton abundance occurred in late summer or fall. The most abundant group were the copepods, mostly _Pseudocalanus_ spp., _Oithona helgolandica_, _Paracalanus parvus_, _Acartia longiremis_, and _Oncaea borealis_. Abundance of copepods peaked at about 12-14,000/m^3 (VTN 1983h, pp. 47-55). Highest abundance was in the upper 80 ft (VTN 1981e, pp. 57-58), with density below that depth only 17 percent of surface waters during 1980 in Boca de Quadra (VTN 1980c, p. 68). These organisms feed mainly on diatoms in the epipelagic zone area. Nonselective feeding zooplankton such as the larvaceans, which are filter feeders, and tintinnids (microzooplankton), which prey on small algae cells, are also common. These organisms are important as they pass on the energy of microflagellate algae to higher trophic levels. Other less frequently occurring zooplankton, such as _Limacina helicina_ and a Cladoceran _Evadne nordmanni_ are often prey for herring, sandlance, and juvenile salmon in the fjords.

The mesopelagic zone has a different assembly of organisms. The majority of the six characteristic species migrate from these areas during the night to the epipelagic area. The most important of these are preferred food for important marine fish species, such as the euphausiids, _Calanus_ spp., and _Parathemisto pacifica_. The most abundant mesopelagic species was the copepod species _Metridia pacifica_, but it spends its early development in the epipelagic areas.

Apparently the most significant zooplankton predators are jellyfish found in both fjords. It was estimated that if the populations remained at the peak density found in these fjords (1/25 m^3) they could sweep clear the entire epipelagic zooplankton population within 100 days (VTN 1981d, p. 59). Because these organisms do not supply direct food to other organisms, their presence in high numbers could greatly reduce success of other organisms of upper trophic levels (e.g., salmon, herring, sandlance, larvae of shrimp, crabs, and other fish). Their feeding also could control summer phytoplankton blooming in Boca de Quadra by removing herbivorous zooplankton (VTN 1983h, pp. 46-55).

Effects of Environmental Conditions:

When information specific to project area fjords was not available, other relevant literature sources were used as a basis for the following discussion.

Temperature and salinity affect growth and survival of important species. Reed (1969) found that temperatures below 50°F reduce survival of larval dungeness crabs in Oregon. In the project area, dungeness crab larvae abundance had already started to peak prior to the fjords warming to 50°F in the spring (VTN 1982g, Appendix A, 1982j, pp. 12 and 34). Survival of larval dungeness crabs is greatly reduced when salinity is less than 20 to 25 parts per thousand (ppt) (Reed 1969). Surface salinity in the upper 6 ft and occasionally deeper in both fjords was often below this level from May to July (VTN 1982g, Appendix A). Similar factors could affect other crab and shrimp species, although low temperatures may have less of an impact on some species such as tanner crab (Ito and Ikehara 1971).

Dissolved oxygen levels near the bottom of the fjords are near toxic levels (less than 3 mg/l) and may naturally restrict the occurrence and distribution of some species below 490 ft.

The size and composition of particles in the bottom sediment has a significant influence on distribution and abundance of some organisms, especially infauna. For example, a Corophrium sp. (a small amphipod) was only found in abundance in fine sediment (mainly silt-clay) in Grays Harbor, Washington, and was greatly reduced in abundance when bottom composition was changed to fine sand (Smith et al. 1976). Some infauna are especially susceptible to changes in sediment quantity input because of their low mobility (Turk and Risk 1981, p. 647). Additionally, the organic content of the bottom substrate can impact the distribution of some organisms that are associated with sediments and are dependent upon detritus as a source of food.

Commercial and Recreational Harvest:

The commercial value of shellfish caught in Boca de Quadra is considerably higher than in Wilson Arm/Smeaton Bay, although the recreational catch in Wilson Arm/Smeaton Bay is probably greater than in Boca de Quadra (ADF&G 1980). This may be a reflection of the size and distance of the two fjords as Wilson Arm/Smeaton Bay has only about half the surface area of Boca de Quadra but is closer to Ketchikan's recreational boaters. The peak commercial value (exvessel value) of shrimp captured with pots (mainly spot and coonstripe shrimp) annually exceeds $47,000 and $7,000 at current rates in Boca de Quadra and Wilson Arm/Smeaton Bay, respectively (see Appendix G, Section 7 for

calculations). Peak values of dungeness crab are about $5,900 and $2,500 annually in Boca de Quadra and Wilson Arm/Smeaton Bay, respectively. Tanner crab and pink shrimp are probably not harvested in these bays (Koeneman 1983a). Nearly all tanner crabs caught in the fjords have been less than legal size (140 mm) (VTN 1981d, Figure 4.3-33, 1982b, Figure 4.3-20 and 21, 1982g, Appendix Tables 25 and 26) and thus of little commercial value. It is possible that resident tanner crabs migrate out of the area and become commercial size. But data from another area of Alaska found an average migration distance for tanner crab of only 15 mi (Donaldson 1980, p. 5). Considering these migration data, tanner crabs that were captured in Boca de Quadra or Smeaton Bay would probably not travel far from these areas during a lifetime. Also no commercial harvest of tanner crab occurred between 1970 and 1974 within the entire District 1 of Alaska, which includes the area around Ketchikan and east. Harvest since 1975 has averaged 1,500 pounds, less than 0.1 percent of all of the southeast Alaska catch (Koeneman 1983b). Therefore, commercial harvest of tanner crab reared in this area is very low. Although pink and sidestripe shrimp may be harvested in these fjords, current levels of harvest in all of District 1 are very low. During 1982-83 only two landings by shrimp beam trawl occurred out of a total of 362 in all of southeast Alaska (Koeneman 1983b).

Marine Plants

Marine plants were studied in detail by VTN in Boca de Quadra and Wilson Arm/Smeaton Bay (VTN 1980c, 1981d, 1982f, and 1982g). The main emphasis concerned phytoplankton and attached macrophytic algae. Samples were collected in the open water areas of the major bays and basins at Boca de Quadra and Wilson Arm/Smeaton Bay for phytoplankton abundance, species composition, chlorophyll *a*, and primary production measurements. Macrophytic algae abundance and species composition were assessed in conjunction with benthic studies, and incidental observation of eel grass locations were reported. Estuarine sedges, grasses, and herbs were also studied and are discussed more completely in Section 3.2.3.

In both fjords the peak period of phytoplankton primary production, chlorophyll *a*, and phytoplankton abundance in the epipelagic area typically occurs in the spring (March-May), during which diatoms dominate, mainly *Chaetoceros debilis*, *Skeletonema costatum*, and *Thalassiosira nordenskiodii*, with densities as high as 5×10^6 cells/liter. During other periods dinoflagellates are the major contributor to abundance and primary production, mainly *Peridinium*, *Cryptomonas*, and *Gymnodinium* (VTN 1982g, pp. 26 and 93).

There is no fundamental difference in standing stock or factors affecting the standing stocks in the two fjords (VTN 1983h, p. 40). Peak spring bloom appeared to occur in areas of 27-30 ppt salinity and

6-8°C in both fjords. Some within-fjord differences were observed, such as the peak of spring bloom occurring near the Wilson Arm/Smeaton Bay intersection. Standing stock chlorophyll a and primary production were often higher in the middle basin than the inner basin of Boca de Quadra (VTN 1983h, pp. 25-33).

The spring bloom of phytoplankton is important because many marine organisms, including recently hatched larvae of crabs, shrimp, and bottom fish, rely upon it either directly or indirectly for their food source (VTN 1982h, p. 63, 1982j, p. 50, 1983d, p. 150; Simenstad et al. 1979, p. 21). Phytoplankton production is apparently the major source of organic carbon to these fjords.

The dominant attached macrophytic algae is *Fucus distichus*, which is abundant in the rocky intertidal and along intertidal rock walls and on hard substrates in soft bottom intertidal areas of the fjords (VTN 1981d, pp. 159 and 174, 1982f, pp. 53 and 63).

Subtidal attached macrophytic algae include mainly reds (e.g., *Ahnfeltia*) and browns (e.g., *Laminaria*) (VTN 1981d, p. 172). Some macrophytic algae (e.g., *Laminaria*) are fed upon by snails and sea urchins (Mann 1973), and provide cover and habitat for other marine organisms. All macrophytes contribute organic carbon (e.g., detritus) to the fjord, particularly *Fucus*, which has a high standing stock biomass. Through death and decay they will ultimately contribute to detritus eating organisms, which are a large and important component of the marine ecosystem (Simenstad et al. 1979).

Eelgrass beds are found in both fjords on sand bottom areas typically in gently sloping areas 0-10 ft deep (VTN 1980c, p. 74, 1981d, p. 183). Although these areas are fairly restricted in the fjord because of steep, rocky shoreline, they are good habitat for many marine organisms and often have a very high abundance and diversity of organisms (Simenstad et al. 1979). They were observed to be good habitat for dungeness crab in Wilson Arm (VTN 1983h, p. 101).

Food Webs

In the Integrated Data Analysis, Coastal and Marine Biology Program Report (VTN 1983h), VTN summarized all of the known information gathered on the two fjords and synthesized their results into food web descriptions and diagrams. This information is the best to date on the dynamics of food transfer between organisms within these fjords. The following is adapted directly from their report, pp. 148 to 157.

Overview:

Energy flow concepts are often represented graphically in the form of food webs, using arrows to show the direction of energy transfer,

primarily through feeding. Information from a number of sources was used to construct food webs for the marine habitats of the fjords. A synthesis of Puget Sound, Washington, food web relationships (Simenstad et al. 1979) was of particular value due to its thoroughness and the similarity of Puget Sound and southeast Alaskan fauna and flora. Other works used included Hart (1973). Feeding habit information for a number of species was obtained directly from specimens collected in the fjords. These species included flathead sole, walleye pollock, blackbelly eelpout, shortfin eelpout, surf smelt, longsnout prickleback, blackfin poacher, Pacific cod, snake prickleback, sandlance, herring, pink salmon, chum salmon, spiny dogfish, quillback rockfish, and yelloweye rockfish. This information is reported for salmon (VTN 1981c, 1982e), herring (VTN 1982i), and a few of the other species (VTN 1982h); the rest has not been reported.

The food webs presented here are a summarization and simplification of real conditions; the actual systems are much more complex than diagrammed. Only organisms thought to be ecologically important, as a result of analyzing several years of data and reviewing other studies, were included. The intent is to illustrate the major energy pathways operating in the five fjord habitats. Variability in feeding habits due to age, abundance, and occurrence was generally not incorporated into these food webs. The relative importance of prey items to single species of consumers was not considered, except in the sense that the relationships shown are thought to be major. Figures 3-34 to 3-38 illustrate the major food webs of the area.

Fjord Habitats:

Epipelagic - The epipelagic habitat is the only habitat in which phytoplankton production is the major source of energy. The epipelagic food web (Figure 3-34) is quite short when compared to those for most other habitats. These short food chains result in an efficient rate of energy transfer, thus supporting large populations of primary carnivores, such as herring. Herring support great numbers of birds and mammals. Phytoplankters and copepods form the foundation of the epipelagic food web.

Mesopelagic - The mesopelagic habitat supports the shortest food web of the five marine habitats (Figure 3-35). Organic matter from the overlying epipelagic habitat, in the form of zooplankton fecal pellets, carcasses, particulate debris, and phytoplankton cells, is the basic source of energy in this habitat. Euphausiids and copepods are the major primary consumers in the food chain. Some of the consumers, including euphausiids, are vertical migrators, feeding in the epipelagic habitat during night. This vertical migration and the incursion of demersal species into the mesopelagic from below tend to blur the boundaries of this habitat. The relative environmental stability of the mesopelagic habitat supports very large populations of

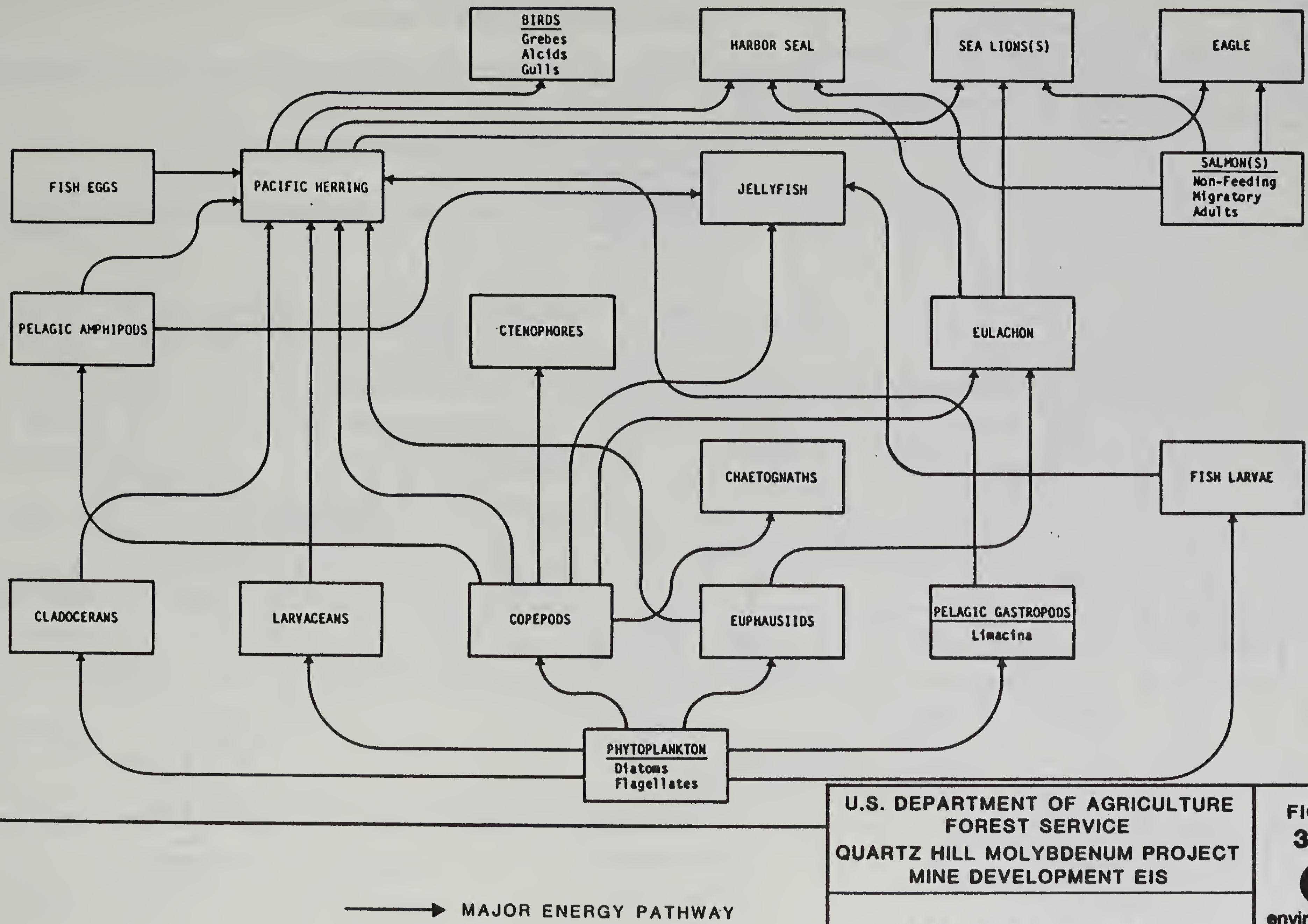

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FIGURE 3-34

EPIPELAGIC FOOD WEB

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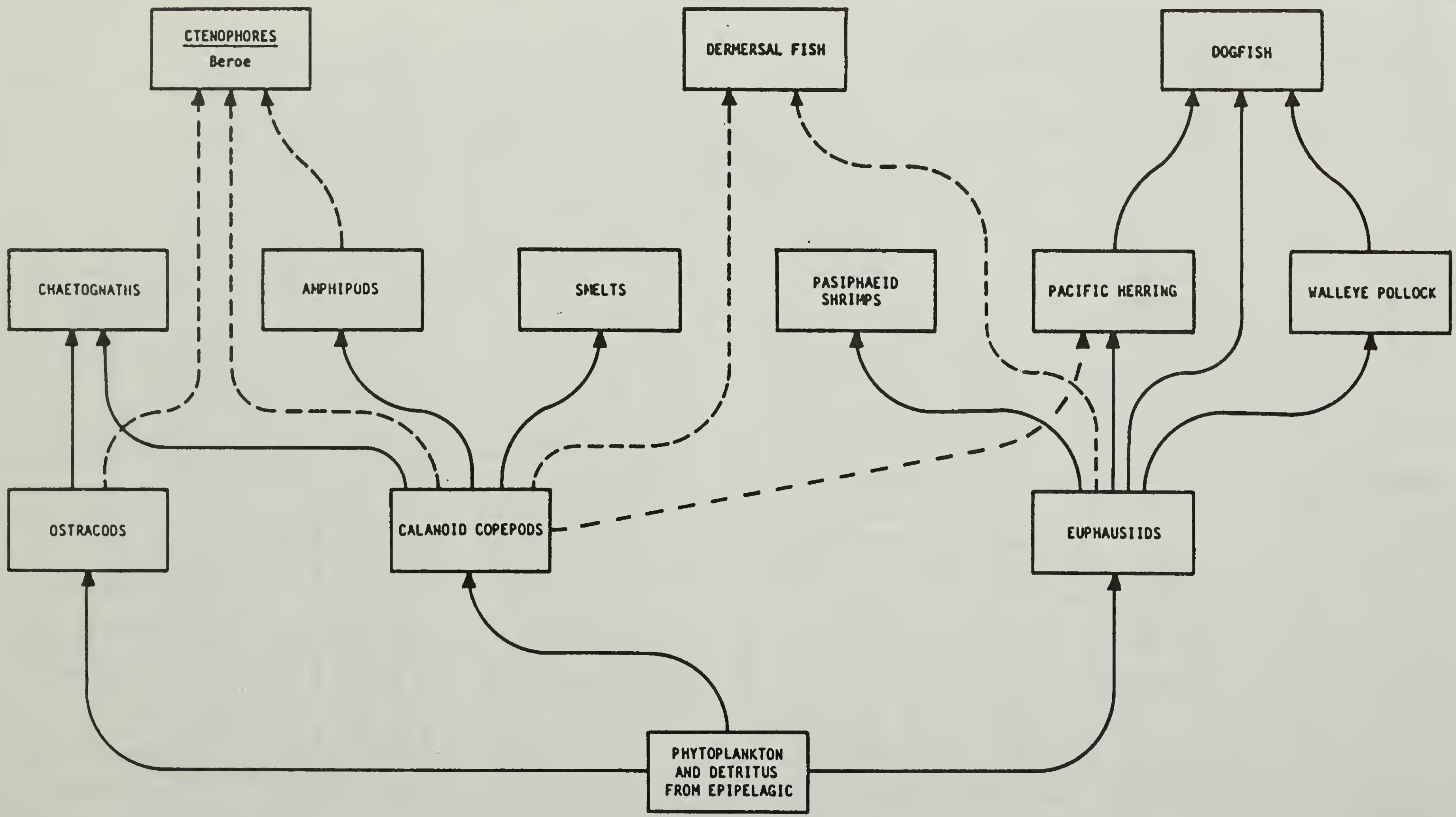
SOURCE VTN 1983d DATE



——→ MAJOR ENERGY PATHWAY

- - -→ MINOR ENERGY PATHWAY

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MESOPELAGIC FOOD WEB

SOURCE VTN 1983d DATE

FIGURE 3-35

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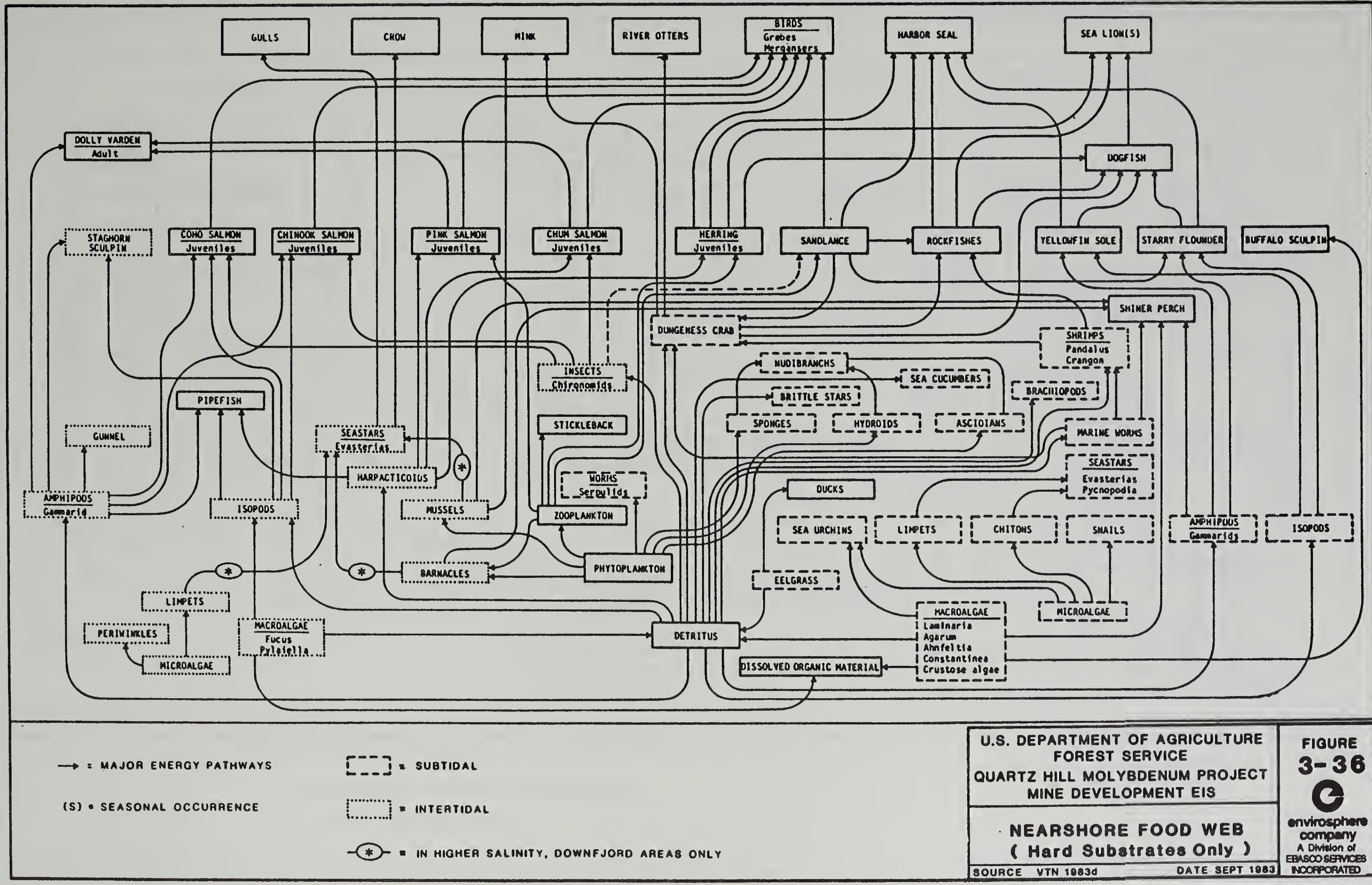

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NEARSHORE FOOD WEB
(Hard Substrates Only)

SOURCE VTN 1983d DATE SEPT 1983

FIGURE 3-36

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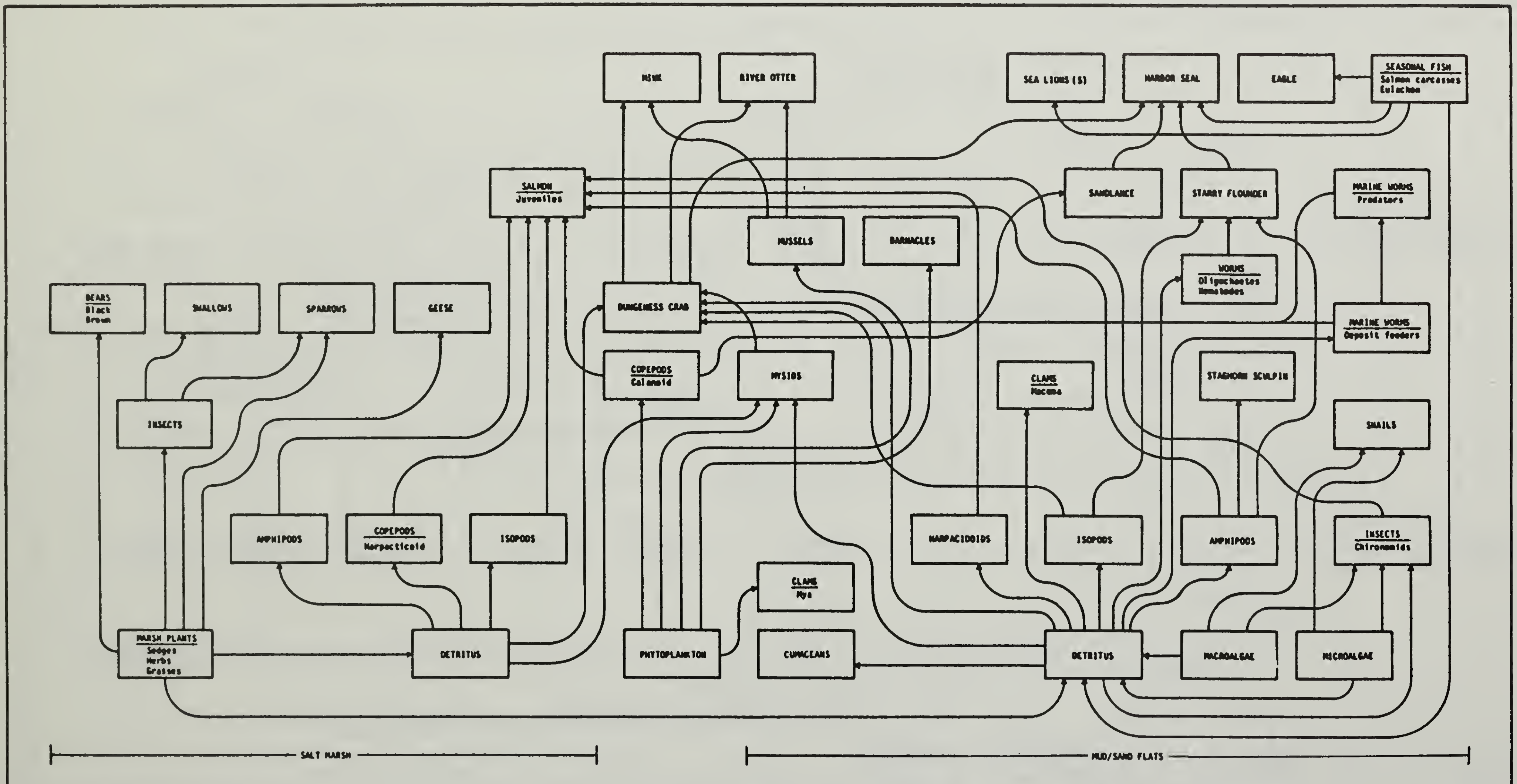

(S) = SEASONAL

→ = MAJOR ENERGY PATHWAY

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ESTUARINE FOOD WEB

SOURCE VTN 1983d DATE SEPT 1983

FIGURE 3-37

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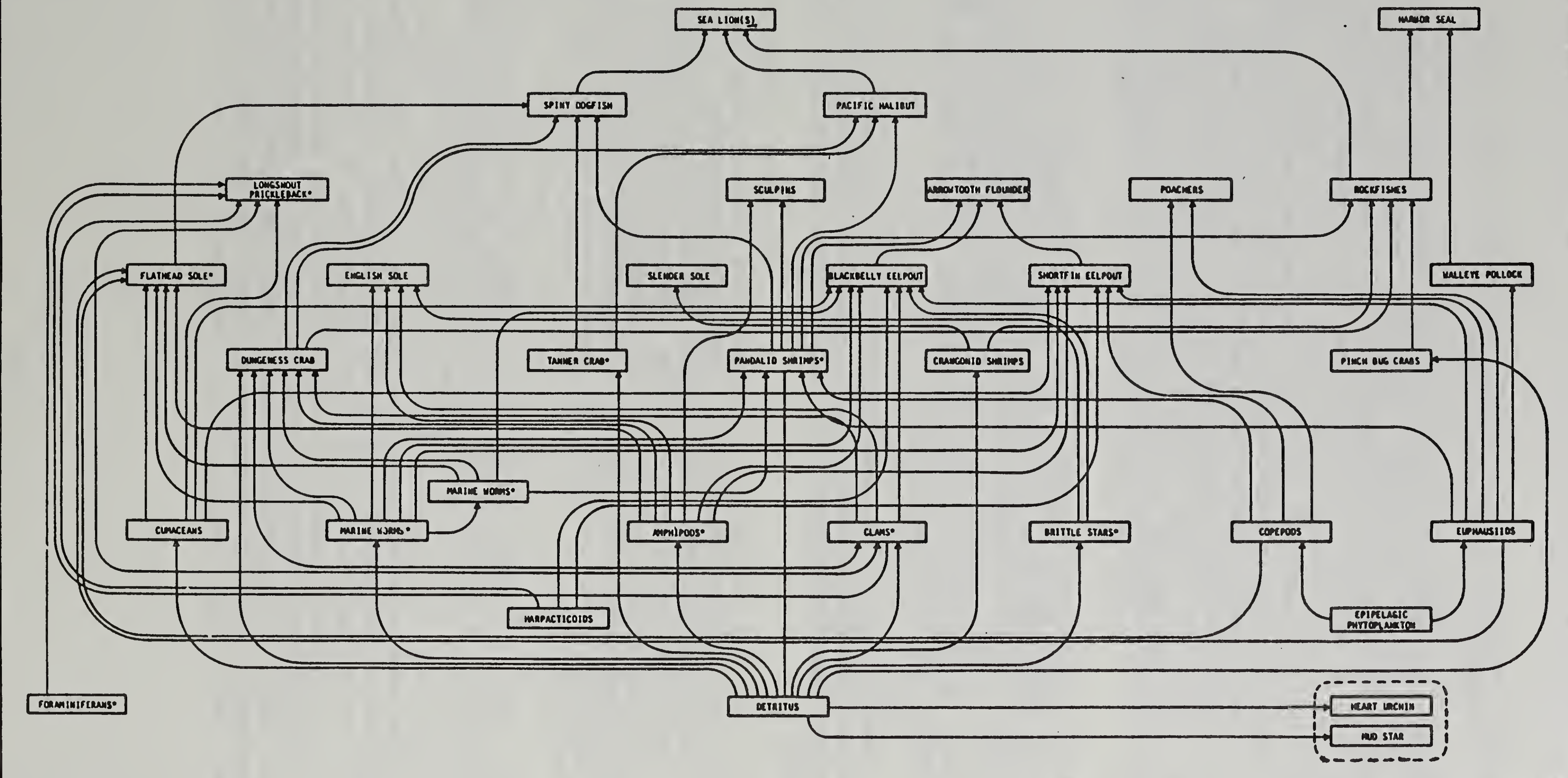

→ MAJOR ENERGY PATHWAYS

* = ORGANISMS CHARACTERISTIC OF DEEPEST AREAS

[dashed box] = FOUND ONLY IN DEEPEST AREAS

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DEEP BENTHIC FOOD WEB

SOURCE VTN 1983d DATE SEPT 1983

FIGURE 3-38

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relatively few species; interspecies competition is not as great a factor in controlling populations levels.

Nearshore - The nearshore habitat food web (Figure 3-36) is based on inter- and subtidal substrates. The base of energy for this system is primary production from a combination of phytoplankton, macroalgae, and microalgae, in addition to allochthonous and autochthonous detritus. Phytoplankton cells are utilized directly by filter feeders. Predation on these filter feeders is very low, resulting in large populations of these animals. Mussels and barnacles, which are preyed upon by sea stars in most coastal systems, are isolated from these predators by low salinities in the inner parts of the fjords. Some sea star predation occurs intertidally in the midfjord regions and near the fjord mouths. Shiner perch, abundant in nearshore waters during the summer, feed on a variety of items, including small mussels, barnacle appendages, and algae.

Rockweed (Fucus) is the dominant macroalgae intertidally. Few organisms were identified as rockweed grazers; however, this plant is important in detrital pathways and also supplies dissolved organics to the water column. Several algal species are found subtidally; these are grazed by sea urchins and, like rockweed, are important suppliers of detritus and dissolved organics.

The consumer levels in the nearshore food web include animals from terrestrial habitats as well as marine species. Detrital-based food chains are important to many fish, including the economically important salmonids.

The diversity and complexity of the nearshore food web tends to minimize the relative importance of any one species group. Detritivores such as amphipods, isopods, and harpacticoid copepods are major food items for a variety of high consumers. Environmental conditions may also change the relative importance of species; an example is the greater utilization of harpacticoid copepods by juvenile pink salmon during early spring 1981 when calanoid copepods were not available (VTN 1981c).

Estuary - The salt marsh and mud flat systems of the estuarine habitat (Figure 3-37) are separated to illustrate different energy pathways. Detritus plays a major role in the mud flat and marsh systems, providing energy to a variety of detritivorous animals. Emergent vegetation, dominated by the sedges (Carex spp.), provides a great deal of detritus to the estuarine system as well as being the base of several terrestrial food chains. Phytoplankton in the estuarine water column is utilized by zooplankton and filter feeding benthic animals. The phytoplankton community of estuarine waters is composed of the same species found in the epipelagic habitat, with the addition of benthic diatoms and other plants associated with mud flats and the freshwater system. The seasonal spawning runs of anadromous fish in the Wilson,

Blossom, and Keta rivers attract a large number of large animals and birds to the estuaries. Salmon carcasses are a major seasonal input of detritus and nutrients to the system. The number of salmon spawning in each river ranges from 20,000 to >100,000 fish annually; the number of carcasses transported into the marine habitats has not been documented, but is probably substantial.

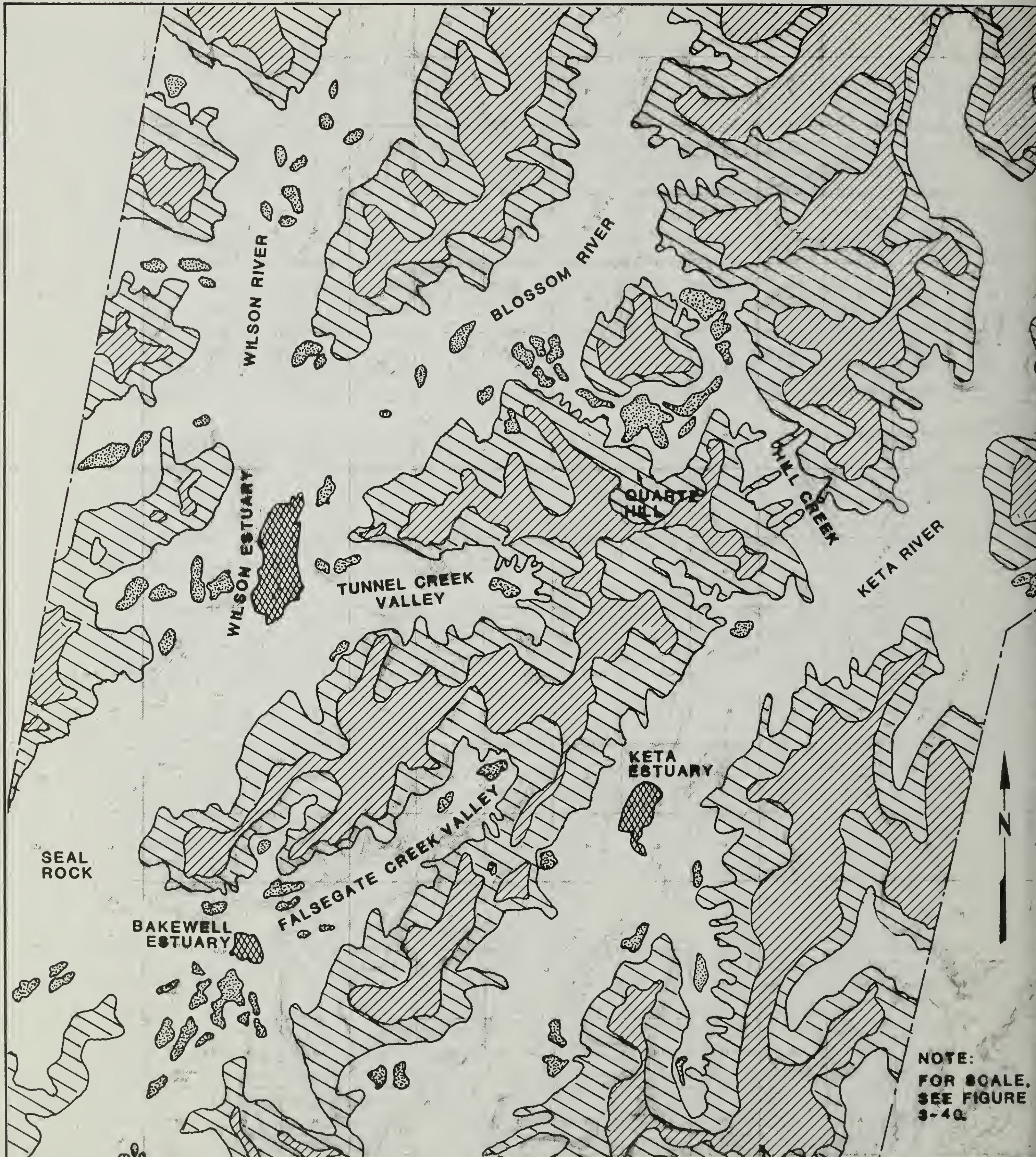
Deep Benthos - The deep benthic food web (Figure 3-38) is supported entirely by detritus. Shallower areas of this habitat, such as at the heads of the fjords, have more species and more pathways into other habitats. Mesopelagic euphausiids and copepods are important food items to several species in the shallower parts of the deep benthic community. Many of the detritivores are deposit feeders. A number of clams and marine worms are filter feeders that create water currents in order to pass particle-laden water over filtering structures.

The nature of the basin sediments creates a reducing environment, which results in oxygen depletion at depths below several centimeters. Burrowing organisms generally maintain contact with the overlying water column in order to obtain oxygen. Some organisms in this habitat, such as the mud star *Ctenodiscus crispatus*, are known to be adapted to periods of oxygen deficiency and high concentrations of hydrogen sulfide (Shick 1976). Oxygen depletion has been described as a natural event in certain fjord basins such as Howe Sound in British Columbia (Levings 1980). The cycle of depletion and periodic renewal is an important physical factor that influences the composition of deep basin communities and, therefore, the trophic structure of those communities.

3.2.3 Vegetation and Wetlands

The vegetation in the Quartz Hill area is typical of coastal southeastern Alaska, characterized by evergreen forests, extensive muskeg, and high topographic relief. Upslope from the forests is low-growing subalpine and alpine vegetation. Six major vegetation types have been identified (VTN 1980d, p. 5), which correspond to the major wildlife habitat types (Figure 3-39): forest (about 50 percent of the project area), alpine vegetation (about 20 percent), muskegs (about 10 percent), estuarine marsh and freshwater marsh (about 3 percent), and subalpine, riparian, and avalanche chute types (most of the remaining 17 percent). The vegetation has been further divided into 17 subtypes (VTN 1980d, Table 1-1) and 14 vegetation subtypes at proposed facility locations are described (VTN 1982c, p. 13).

The vegetation types of greatest importance to man are the estuarine marsh and the forest. The estuarine marsh type is important because of its contribution to the maintenance of the salmon runs, input of nutrients to adjacent waters, and its value as habitat for waterfowl, furbearers, harbor seals, bears, eagles, and other wildlife. The forest potentially has direct commercial value as well as indirect value as wildlife habitat and is the dominant living landscape feature.



LEGEND

ALPINE

SUBALPINE / AVALANCHE SCRUB

MUSKEG

FOREST

ESTUARINE MARSH

STUDY AREA BOUNDARY

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VEGETATION MAP

SOURCE VTN 1983j | DATE OCT 83

FIGURE 3-39

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Some parts of the forest are inherently more valuable than others. For example, the forest edge (especially in old growth timber) near the estuary is much more valuable as habitat for eagles, deer, and furbearers than the expanse of middle elevation forest (VTN 1983j, p. 15). Forested steep and broken terrain on south facing slopes is often important winter habitat for goats (Smith 1983a). The riparian, alpine, and subalpine vegetation types are next in importance. The riparian habitat, especially at low elevations, is important to bears, furbearers, and eagles (VTN 1983j, p. 15), and protects the streams from sedimentation via erosion of the streambank. The alpine and subalpine vegetations are important as habitat for mountain goats, especially in steep areas with cliffs, and for deer, wolves, and bears (U.S. Borax 1983a, p. 7-45). Muskeg areas are relatively less important as habitat for wildlife species, although bears may forage for berries there, and muskegs may serve as wildlife movement corridors (U.S. Borax 1983a, p. 7-45). Muskegs also regulate groundwater recharge, thus affecting streamflow in salmon and trout streams.

Important Vegetative Assemblages

Wetlands:

Of the six major vegetation types found in the Quartz Hill project area, those identified as wetlands have special importance recognized by separate regulatory status under Section 404 of the Clean Water Act. Six types of wetlands will be affected by the project (VTN 1982k, p. 16): shallow open water, marsh, swamp, peatland (muskeg), meadow, and wetlands within riparian areas (rocky intertidal areas are discussed with aquatic resources, Section 3.2.2). Distribution of the most widespread types, muskeg and estuarine marsh, is illustrated in Figure 3-39. As discussed above, the most important of the six is estuarine marsh. These sedge-dominated marshes are productive fish and wildlife habitat. The estuarine marsh on the Wilson River delta (including the mouth of Tunnel Creek) occupies about 320 ac, the marsh on the Keta River delta (including the mouth of Aronitz Creek) covers about 200 ac (Forest Service 1982a, p. 3-17), and the marsh in the Bakewell estuary covers about 100 ac. Riparian habitat is a narrow strip of variable width with boundaries that are indistinct from adjacent forest and that contains scattered wetland areas. Riparian habitat along lower stretches of rivers is most important for wildlife (U.S. Borax 1983a, p. 7-45, 1983b, p. 13). The acreage is estimated to be one to three times that of the estuarine marsh. Riparian habitat along the rivers includes several wetland types (VTN 1983j, p. 9), and often includes deciduous trees (e.g., black cottonwoods).

The other four wetland types are individually less important than estuarine marshes and riparian wetland areas. The muskegs (peatland types) are extensively distributed in the project area and comprise three subtypes, all with peat soils (VTN 1982k, pp. 21-23). Bogs are characterized by sphagnum mosses, while fens and transitional peatlands

are dominated by sedges and mosses other than sphagnum. Where trees occur in peatlands they are usually stunted and sparse (VTN 1982k, p. 22). Wetland meadows occur in alpine and subalpine habitats and along streams. They usually have mineral soils, are dominated by grasses, forbs, and sedges (Runka and Lewis 1981), and may be used as foraging areas for mountain goats and bears (VTN 1983j, pp. 16 and 17). Individual meadows are often small and scattered. Swamps are shrub or tree covered wetlands dominated by surface or subsurface water. They are found along the Keta and Blossom rivers and in the Beaver Creek valley (VTN 1983j, p. 20). Their importance to wildlife depends on their proximity to other important habitats due to the edge effect. The open standing water type, associated with lakes, and freshwater marsh type, associated with lakes and beaver ponds, are not common in the project area. From a regional perspective, none of the wetland types are rare or unique.

Forest:

Forests extend from sea level to about 2,500 ft elevation and cover about half the land area (Forest Service 1982a, p. 3-6). These mature forests are dominated by Sitka spruce, western hemlock, and mountain hemlock, with local occurrence of red and yellow cedar, red alder, black cottonwood, and lodgepole pine (VTN 1983j, pp. 1 and 2). The forests have been subdivided into about seven subtypes (VTN 1980d, Table 1-1), which reflect forest adaptation to soil, drainage, elevation, and other physical factors. None of the forest types show signs of logging or fire.

Forest fringes are of greatest importance to wildlife, and the lowest elevation forest is the most important fringe. Old growth, uneven aged stands of forest near waterways are the areas selected by eagles for nesting (Hodges and Robards 1982), and these stands are also the areas of greatest value as deer winter range during severe winters (Wallmo and Schoen 1980). This is prime habitat where several furbearers (e.g., mink, otter, and marten) are trapped (Wood 1983a). Bears use these areas as cover near estuarine and riverine foraging areas, and well-drained forest is important for denning sites (Erickson et al. 1982). Steep areas in the upper elevations of forests are important for mountain goats as winter habitat (Smith 1983a), and wolves, wolverines, and several small mammals and bird species also use these areas.

Other Nonforested Areas:

The subalpine and alpine zones each cover about 20 percent of the land area above 1,800 ft elevation (Figure 3-39). Avalanche chutes occur on steep slopes and extend from alpine zones to forested valley floors. Vegetation, repeatedly disturbed by avalanches, ranges from nearly bare rock to a dense scrub of Sitka alder and Sitka willow and conifer seedlings. The dense thickets are sometimes used by mountain goats as secluded places to bear their young (Smith 1983b). Lush subalpine and

alpine meadows, especially those near rock outcrops and cliffs, are important grazing areas for mountain goats, especially during summer (VTN 1983j, p. 33). Alpine areas are also important summer range for deer.

Distribution of Vegetation in Development Areas

The distribution and relative abundance of vegetation subtypes in the potential development areas of the Quartz Hill project area were compiled by VTN (1982k, p. 13). This information, presented in Appendix H, Table H-1, shows that forest dominates most of the development areas.

Important Species

No threatened or endangered plant species are known to occur in the Quartz Hill area (see Section 3.2.5), but three species that are on the U.S. Forest Service rare plant list have been found (VTN 1982k, p. 14). Northern wild licorice (*Galium kamtschaticum*) was found in the upper Falsegate Creek valley, Davy mannagrass (*Glyceria leptostachya*) was found along the Wilson River, and ciliate hedge-nettle (*Stachys mexicana*) was found along Tunnel Creek and the Wilson River. An additional 25 species from the Forest Service list and 4 species currently under review by the U.S. Fish and Wildlife Service as threatened or endangered, and which may occur in the project area, are listed in Appendix H, Table H-2.

Several common plants are of particular importance to wildlife species, such as huckleberries and other berries as summer bear food; and sedges, grasses, beach lovage, cow parsnip, and skunk cabbage as spring bear food (VTN 1983j, p. 36).

3.2.4 Wildlife Resources

Wildlife studies by VTN (1980d, 1981f, 1982k) have recorded 22 mammal species, 111 bird species, and 1 amphibian species in the Quartz Hill area. Species of particular importance to man include the mountain goat, black bear, brown bear, and bald eagle. These species are important because they are relatively common in the project area and are recreationally valuable or are protected by state or federal laws. Several other species are also important because they are somewhat recreationally important or are especially vulnerable to impact.

Important Wildlife Species

No threatened or endangered species reside in the Quartz Hill project area (see Section 3.2.5). The bald eagle, although not threatened or endangered in Alaska, is protected by the Bald Eagle Act of 1940 and by a Memorandum of Understanding (1984) between the Forest Service and the U.S. Fish and Wildlife Service (USFWS). The memorandum specifies that individual bald eagles, their nests, and nest trees shall not be

disturbed or destroyed. Modification of the guidelines of the memorandum require a specific variance from the USFWS.

Bald Eagles:

Bald eagle abundance and use of the project area varies seasonally. When nesting begins in early April, eagles are dispersed throughout the region along water bodies. Nest trees are usually within 200 yd of saltwater or a nearby river or lake in old growth forest (Hodges and Robards 1982). Nests are usually in the upper half of large, live Sitka spruce or western hemlock trees. Eagle nest distribution in the Quartz Hill area is illustrated in Figure 3-40. Young eagles are fed fish and other aquatic life, especially herring where they are available. In late July salmon runs begin and eagles congregate along the estuaries and lower stretches of rivers. The young-of-the-year leave the nest by mid-August and join the adult and subadult eagles along the rivers (Prather 1983). Peak numbers of eagles are along the rivers in August (VTN 1982k, p. 61). As salmon availability decreases, eagles disperse and attain their lowest densities from November to April. In March, densities along the Wilson River swell briefly to summer levels in response to a smelt (eulachon) run in the Wilson River. Appendix H, Figure H-1 presents eagle sightings in 1982 as representative of the seasonal and spatial distribution of eagles in relation to fish abundance. Eagle roost and perch trees have not been identified in the Quartz Hill studies, but some trees are preferred for these purposes.

Throughout the year, the narrow strip of habitat adjacent to the fjords, estuaries, and lower rivers is of greatest importance to bald eagles for nesting and feeding. Table 3-12 compares the amount of eagle habitat and the number of eagle nests associated with each waterway in the project area. Based on the number of nests per mile of shoreline, the estuaries are most important. Estuaries supported an average of 1.86 nests per mile of shoreline versus 0.45 for fjords and 0.36 for rivers. The average nests per mile in the Smeaton/Wilson system and in the Boca/Keta system are within the range of 0.20 to 1.05 nests per mile of shoreline (average 0.80) for all of southeast Alaska (Appendix H, Table H-3).

Mountain Goats:

The mountain goat is a prized game animal in the Quartz Hill area. The ADF&G has conducted aerial surveys of goats since 1968 in their K-4 area (Figure 3-41), which closely coincides with the Quartz Hill project area. Mountain goat abundance in the K-4 area is similar to surrounding survey units (Table 3-13). A recent study by Smith and Bovee (1984) has estimated goat densities in the K-4 area at 4.38 ± 0.89 goats/km^2 on the winter range and 2.29 ± 0.47/km^2 for year-round habitat density. A large population decline in the region

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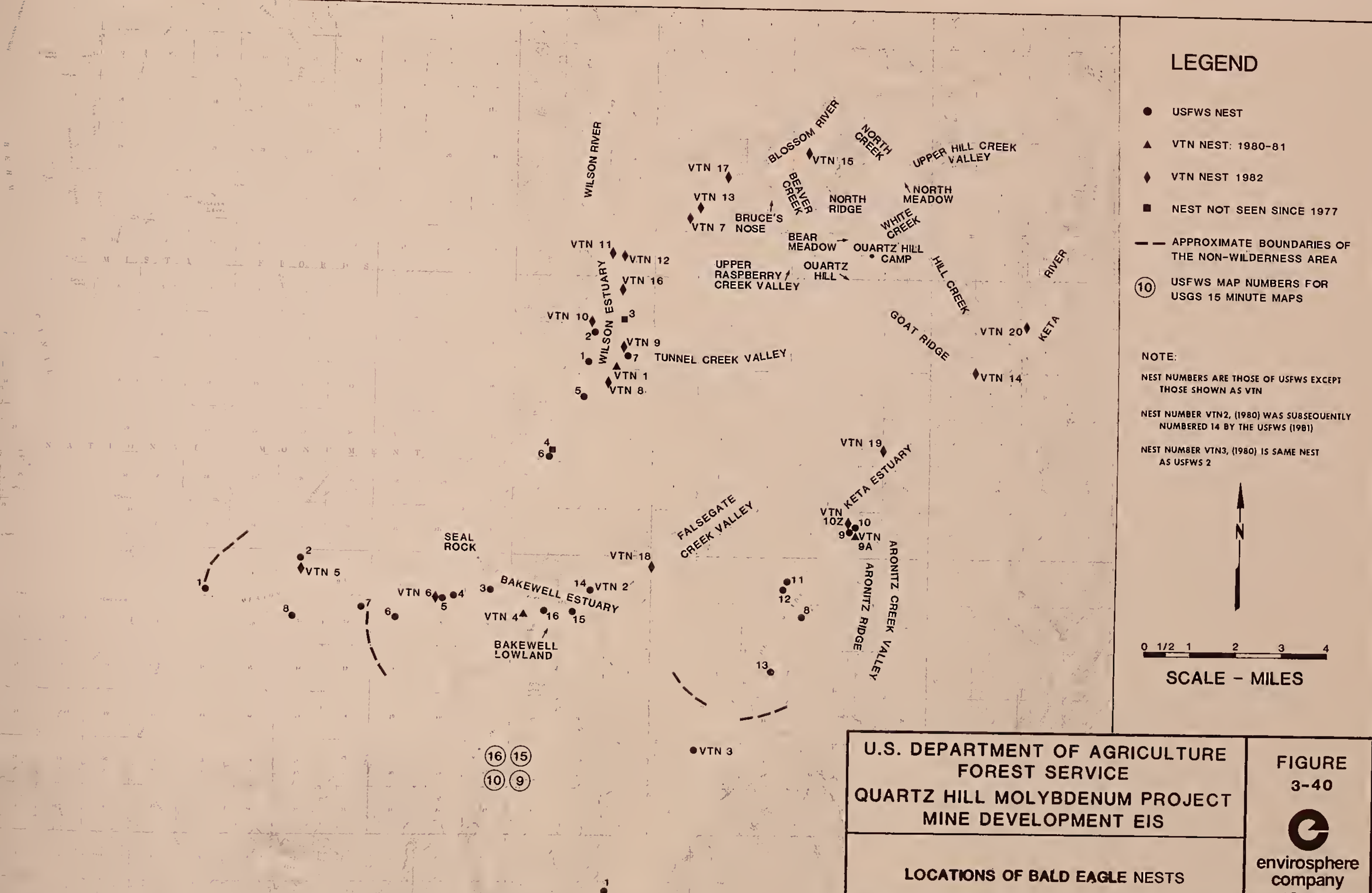

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FIGURE 3-40

LOCATIONS OF BALD EAGLE NESTS

SOURCE VTN 1983) DATE OCT 83

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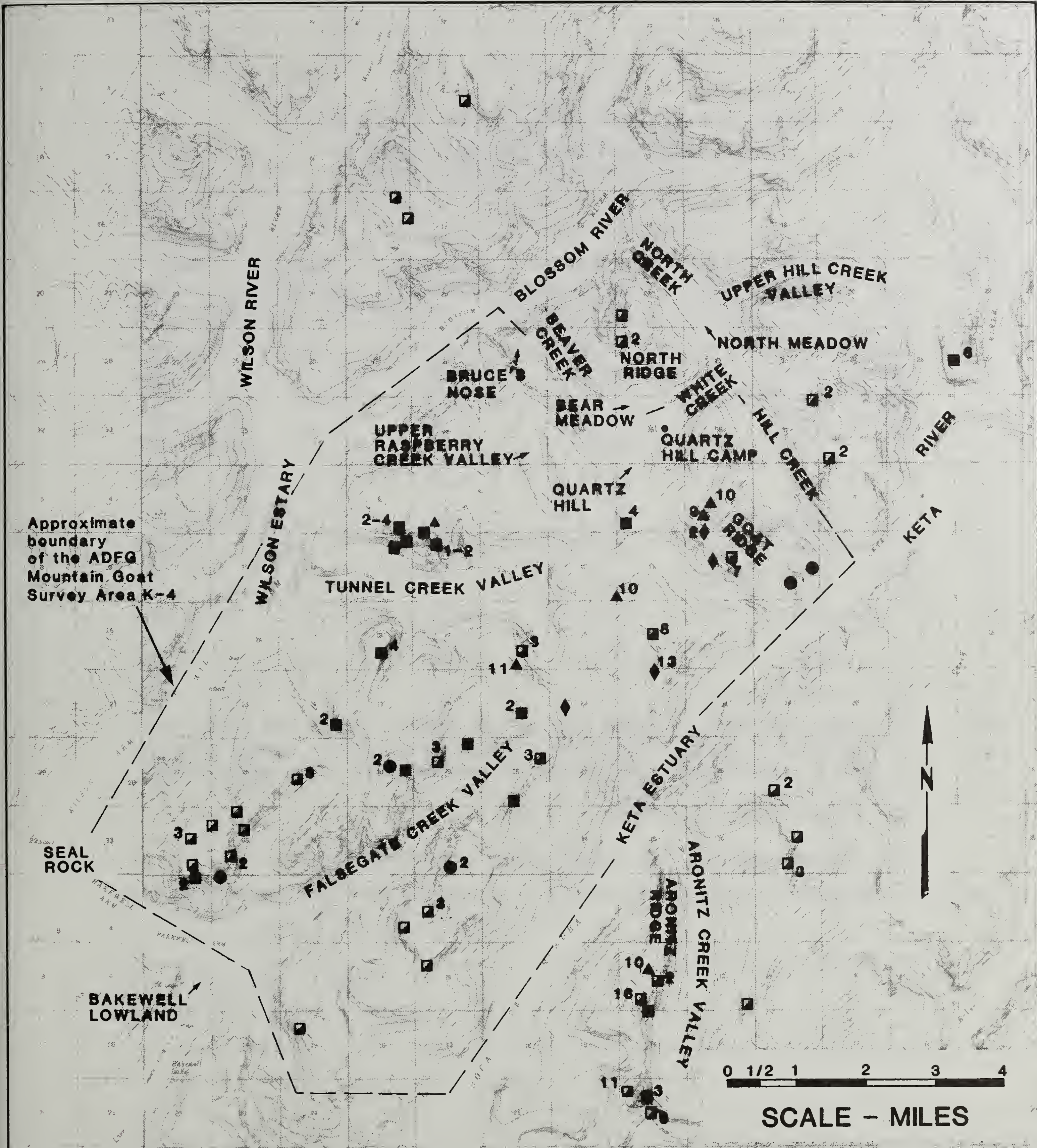

LEGEND

- SUMMER 1980 (June & August)
- WINTER 1981 (February & April)
- SUMMER 1981 (August)
- WINTER 1982 (February & March)
- SUMMER 1982 (July & August)
- 5 NUMBER OF GOATS SIGHTED

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LOCATION OF MOUNTAIN GOAT SIGHTINGS (1980 - 1982)

SOURCE VTN 1983j DATE OCT 83

FIGURE 3-41

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TABLE 3-12

EAGLE HABITAT1/ AND EAGLE NESTS IN THE QUARTZ HILL PROJECT AREA2/

Water Body	Miles of Shoreline	Acres of Habitat1/	Number of Nests	Nests per Mile
Smeaton Fjord3/	25.0	1818	120	0.48
Wilson Estuary	3.8	276	7	1.84
Bakewell Estuary	1.2	87	2	1.67
Wilson River	6.8	495	3	0.44
Blossom River	10.4	756	4	0.38
Subtotal	47.2	3432	28	0.59
Boca de Quadra Fjord	10.3	749	4	0.39
Keta Estuary	2.0	145	4	2.0
Keta River	10.4	756	3	0.29
Subtotal	22.7	1650	11	0.48
Total	69.9	5082	39	0.56

1/ Eagle habitat is defined here as all habitat within 200 yd of the water of a fjord, estuary, or river upstream to the uppermost eagle nest. Numbers were calculated from mapped data (U.S. Borax 1983a).

2/ Within the nonwilderness area only.

3/ Includes Smeaton Bay, Bakewell Arm, and Wilson Arm.

TABLE 3-13

RESULTS OF ADF&G AERIAL MOUNTAIN GOAT SURVEYS
QUARTZ HILL AREA (ADF&G AREA K-4)1/2/

Year	Survey Date	Adults	Kids	Unknown	Total	Kids: 100 Adults	Survey Time (min.)	Goats/ Hour	Goats/ Hour in Area K-5 3/
1968	9/17	193	72		265	37	80	199	194
1971	9/15	155	56	9	220	36	70	189	121
1973	8/16	90	13		103	14	65	95	57
1974	8/27 4/	26	8		34	31	36	57	24
1975	8/12	15	3		18	20	47	23	20
1976	9/1	18	7		25	39	57	26	44
1977	9/6	39	19		58	49	56	62	29
1978	9/9	65	19		84	29	51	99	74
1979	9/3	44	16		60	36	65	55	87
1980	8/27 4/	35	18		53	51	42	76	72
1981	9/13	68	27		95	40	47	122	105
1982	9/18	64	23		87	36	62	84	105
1983	9/16 5/	88	26		114	30	63	109	113

1/ See Figure 3-41 for boundaries of K-4. Surveys are estimated to account for 50-60 percent of goat population.
2/ From VTN 1983j.
3/ Area K-5 is from Marten Arm to Portland Canal; source: ADF&G 1983.
4/ Incomplete surveys.
5/ Source: Smith 1984a.

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between 1970 and 1975 was presumably caused by severe winters (Smith 1983b), and the population has recovered since 1975 to about half of the 1968 level. Hunter harvest of goats in the K-4 area in recent years has ranged from zero to four animals total per year and four to seven in adjacent drainages (see Appendix H, Table H-4).

The goats generally occur in small groups and prefer high elevation habitat near steep and broken terrain where they can escape predators. In summer, the goats are in subalpine and alpine habitats above the forest zone. During winter, some goats use areas above treeline and tend to remain as high as conditions permit (VTN 1983j, p. 33). The most important winter habitat, however, is upper elevation forest in steep and broken terrain (Smith 1983a). Goat tracks in winter have been observed from 800 to 3,200 ft elevation (VTN 1981f). Goat winter habitat in the Quartz Hill area, based on tagging studies (Smith 1983a, 1983b), is illustrated in Figure 4-20. Smith and Bovee (1984) estimated 45 km^2 of goat winter habitat in the K-4 survey area. Winter habitat is especially important because food availability in winter is low, and goats rely on food available above the snow, such as mosses and lichens that grow on tree trunks and branches (VTN 1982k, p. 56) and conifer twigs (Fox and Taber 1981). Females seek the seclusion of extremely inaccessible areas to bear their young. During the rut, males may cross the valleys to find other groups (Smith and Raedeke 1983); otherwise, goats seldom come down to the valley bottom unless forced down by unusually heavy snowpack. Smith (1984a) recorded movements of a radio-tagged male back to the Tunnel Creek area during the rut for two years. The goat spent the rest of the year in other mountain peak areas to the northeast across one or more valleys.

Black Bear:

Black bears are common in the Quartz Hill project area as they are elsewhere in southeastern Alaska. No studies of bear densities have been conducted in southeastern Alaska, but hunter harvest records suggest that bears are at least as numerous in the project area as in other parts of the region. One to seven bears have been harvested annually in the Smeaton Bay and Boca de Quadra areas in the project vicinity (see Appendix H, Table H-5), and that represents a larger proportion of the harvest in Game Management Unit 1A than the proportion of the unit represented by the project area (ADF&G 1983).

Black bears utilize all the habitat types in the Quartz Hill area, but use varies with season and habitat (VTN 1983j, p. 36). From the time of emergence from dens in April or May to midsummer, moist lowland areas such as estuaries and riparian areas are heavily used as bears graze on herbaceous plants such as grasses, sedges, skunk cabbage, cow parsnip, and beach lovage. In summer the huckleberries, which are available in patches over much of the study area, ripen and become a

dominant food item. The lower reaches of major rivers and creeks become important as salmon return to them to spawn and bears feed on the salmon. Herbaceous vegetation is important when other food items are not available as in the early spring and late fall until the bears seek dens. Bears den in hollow trees, under logs, and in ground excavations in well drained soils (Erickson et al. 1982).

Brown Bear:

Brown bears have been observed in low numbers (less than 10) in the project area (VTN 1983j, p. 36). They may use all the habitat types in a pattern similar to black bears, but are most often found along estuaries and lower river areas (U.S. Borax 1983a, p. 7-46). Brown bear sightings have been made in the Wilson and Keta estuaries and lower rivers, and one brown bear was killed by a hunter in the Wilson Arm vicinity in 1983 (see Appendix H, Table H-6).

Furbearers:

Several species of furbearing mammals are found in the Quartz Hill project area, and trappers routinely use the area. Species trapped include mink, otter, and marten; the shoreline of the Smeaton Bay area is considered one of the most productive areas for marten (Wood 1983a). Wolves, wolverines, and beavers have been seen in the area (VTN 1982k), but the populations are low, and no specific records of harvest are known. Mink and river otters are found along the edge of the fjord and along rivers, and marten range all elevations. Wolves and wolverines range throughout the project area and spend a significant amount of time at high elevation (Wood 1983a).

Sitka Blacktail Deer:

The Sitka blacktail deer is an important game species in southeastern Alaska, but since 1975 the population in the Quartz Hill area has been low. The severe winters that reduced the mountain goat populations had an even greater effect on the deer population (Smith 1983a). Only a few animals have been reported during environmental studies for the Quartz Hill project (VTN 1981f, p. 57). The Sitka blacktail deer is not an important species in the Quartz Hill area at this time, but if the population recovers to earlier levels, the species would again be considered an important species. Winter habitat at low elevations is in limited supply and therefore is of greatest importance to the species. Old growth timber along lower river valleys, estuaries, and shorelines is such habitat (Wallmo and Schoen 1980).

Marine Mammals:

Marine mammals are highly mobile, and individuals of several species other than those reported could occur in the waters near the project. Gray whales, humpback whales, minke whales, shortfin pilot whales,

harbor porpoises, and Pacific whiteside dolphins are reported for waters of southeast Alaska (Leatherwood et al. 1982). Of the marine mammals observed in the fjords of the Quartz Hill project area, the harbor seal is most abundant. Small numbers of northern sea lions, Dall's porpoises, and killer whales have also been observed (VTN 1982m, 1983i). Harbor seal abundance varies seasonally, generally being highest in summer and lowest in winter, but the largest number observed by VTN was about 200 seals in Wilson Arm during a smelt run in March 1982 (VTN 1983i, p. 6). Seals haul out at selected shoreline locations for resting, molting, breeding, and pupping. Habitats of particular importance include the Wilson and Keta estuaries, important as haul-out areas and as points of concentration of food organisms, and Seal Rock, a haul-out area at the entrance to Bakewell Arm, available at low tide.

Waterfowl:

The estuaries in the Quartz Hill project area are important resting and feeding areas during migratory periods for several waterfowl species, including trumpeter and whistling swans, Canada geese, mallard ducks (and other dabbling ducks), bay ducks, sea ducks, and mergansers. Such wintering areas are in short supply in southeast Alaska. The number of waterfowl is highest in winter, spring, and fall, and lowest in summer (VTN 1983j, p. 25). The Wilson estuary supports more waterfowl than either the Bakewell or Keta estuary (Table 3-14). Enough waterfowl commonly occur there to attract a few waterfowl hunters from Ketchikan (Wood 1983a). Nesting waterfowl are few in the project area, consisting mostly of mergansers and mallards (VTN 1983j, p. 28).

Other Wildlife:

Other mammals that occur in the project area include marmots in high rocky areas near meadows, red squirrels in the forests, and deer mice, lemmings, and other small rodents in various habitats. These species provide much of the prey base for many of the predatory species.

Other bird species are more numerous (VTN 1982k; Appendix H), a few golden eagles have been seen in the project area as well as several hawks and one owl species. Blue grouse have been observed in the valleys and ptarmigan at high elevations. A total of 10 species of shorebirds have been observed, but the numbers are generally low. Gulls are common, and 5 species have been observed, but other marine birds are scarce. The fauna of small birds is reasonably diverse as 38 species of songbirds have been recognized. It is not known how many of these nest in the area.

3.2.5 Threatened and Endangered Species

According to correspondence between the U.S. Forest Service and the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act (Nelson 1983), no threatened or endangered plant or animal

TABLE 3-14

CUMULATIVE ANNUAL WATERFOWL SIGHTINGS BY SPECIES GROUP IN WILSON, BAKEWELL, AND KETA ESTUARIES, 1982 1/

Species	Wilson Estuary	Bakewell Estuary	Keta Estuary	Total
Swans	25-30	15± 2/	0	25-30 3/
Canada Geese	250-285	80± 2/	210-220	520-565 3/
Surface Ducks	345-350	150-155	140-150	635-655
Bay Ducks	135-210	215±	110-145	460-570
Sea Ducks	40-50	25±	10±	75-85
Mergansers	120-125	25-30	85-115	230-270
Total	915-1050	505-520	555-640	1945-2210 4/

1/ Numbers rounded to nearest five. Source: VTN 1983j, Table 1-10.

2/ Some birds believed to use both Bakewell and Wilson estuaries.

3/ Total not additive because of 2/.

4/ Row and column totals not equal due to 2/.

species are known to reside in the Quartz Hill area. Informal consultation was conducted concerning the endangered humpback whale, which has been reported in Revillagigedo Channel near the project area. The Biological Assessment Report written by the Forest Service (Benda 1983a) concludes that the proposed project will not affect the endangered humpback whale. The NMFS concurred with this conclusion (McVey 1983).

3.3 SOCIAL AND ECONOMIC ENVIRONMENT

3.3.1 Socioeconomics

Definition of the Study Area

The local impact area is defined as the Quartz Hill project site and the Ketchikan Gateway Borough (KGB). The KGB is the major transportation, service, and supply center for the southern half of southeastern Alaska, and is therefore where most of the socioeconomic impacts are likely to occur.

The regional impact area is defined as the area within a 150 mi radius of the project site, within Alaska. In addition to the KGB, the area includes the islands of Prince of Wales, Annette, Mitkoff, Wrangell, and portions of Kupreanof. The major communities outside of the KGB and within the regional impact area are Wrangell and Petersburg, approximately 100 and 130 mi by air from the project site, respectively.

Demographic Characteristics

Historical population growth of the local impact area is detailed in a recent study (Entercom 1982a). Population levels in 1970 and 1980 within the local and regional impact areas are shown in Table 3-15. The KGB population grew by around 1.2 percent per year between 1970 and 1980, approximately the same as the growth rate of the regional impact area (1.3 percent). Most of that growth occurred outside of the City of Ketchikan. These growth rates can be compared to those of southeast Alaska and the State of Alaska, which grew by about 2.4 and 2.9 percent per year, respectively.

The KGB conducted its own census in the fall of 1983. The results indicate a July 1983 borough population of 14,551, with the City of Ketchikan population at 8,414, City of Saxman at 343, and the area outside incorporated cities at 5,794. This population estimate assumes a zero housing vacancy rate.

The population characteristics of the KGB have been detailed in earlier studies (Entercom 1982a). The average occupied household size has decreased from 3.26 persons per household in 1970 to 2.55 in 1980, as measured by the U.S. Census, or to 2.76 in 1980, as measured by the

TABLE 3-15

POPULATION, REGIONAL AND LOCAL IMPACT AREAS
1970-1980

	1970	1980	Annual Average Percent Increase	Percent Growth Rate 1970-1980
Local Impact Area				
Ketchikan Census Subarea 1/	10,041	11,316	1.2	12.7
City of Ketchikan	6,994	7,198	0.3	3.0
Remainder of KGB	3,047	4,118	3.1	35.1
Remainder of Regional Impact Area				
Prince of Wales-Outer Ketchikan Census Area	3,782	3,822	0.1	1.1
Outer Ketchikan Subarea	1,676	1,333	-2.3	-25.7
Prince of Wales Subarea	2,106	2,489	1.7	18.2
Wrangell-Petersburg Census Area 2/	4,920	6,167	2.3	25.3
Petersburg Subarea	NA	3,804	NA	
Wrangell Subarea	NA	2,363	NA	
Regional Impact Area Total	18,743	21,305	1.3	13.7
Southeast Alaska	42,565	53,794	2.4	26.3
State of Alaska	302,583	401,851	2.9	32.8

1/ The Ketchikan Census Subarea has the same boundaries as the KGB.

2/ Not all of the Wrangell-Petersburg Census Area is within the regional impact area, but the cities of Wrangell and Petersburg are within the regional impact area and they accounted for over 80 percent of the Wrangell-Petersburg Census Area population in 1980.

SOURCE: Alaska Department of Labor 1980, 1981a, and 1983a.

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Alaska Department of Labor (Entercom 1982a and Alaska Department of Labor 1983a). The 1983 KGB census estimated household size at 2.82 persons. Almost 30 percent of the residents have lived in the KGB less than 5 years. The number of Native (primarily Indian) people in the KGB in 1980 was 1,405, or 12.4 percent of the population (Entercom 1982a).

Economic Base

The economies of the local and regional impact areas are largely dependent on the harvesting and processing of timber and fish products, which have historically exhibited wide cyclical variations. Ketchikan is southern southeast Alaska's center for trade, transportation, and government. The KGB economy also depends on the export of manufactured goods and tourism (Entercom 1982a).

Gross taxable sales in the KGB were about $186 million in 1981, $196 million in 1982, and $236 million in 1983. For those three years, gross taxable sales were highest in the third quarter, which reflects, in part, the effects of tourism on the local economy (KGB 1985). The KGB's role as a trade center is reflected by the fact that 25 percent of annual sales were to buyers outside of the borough via common carriers (U.S. Borax 1983a).

In recent years, the timber harvest in both the Tongass National Forest and in the Ketchikan District has declined significantly from the peak years in the early 1970s. Ketchikan supplies forest products to both the domestic U.S. and export markets, and is therefore susceptible to national and international economic conditions and forces (Research Design Publication, Inc. 1983).

The fishing industry based in the borough is primarily dependent upon salmon. The harvest in the Ketchikan area has been very erratic over the last 30 years. Salmon stocks appear to be on the upswing. Traditionally, most of the salmon has been canned, but the importance of frozen fish products has been growing. In most years, the Ketchikan District has accounted for at least 50 percent of the southeast Alaska salmon catch (Research Design Publication, Inc. 1983).

Tourism has become an increasingly important basic industry in the KGB. Sightseeing and sport fishing are two of the biggest attractions. Ketchikan is the southernmost Alaska port for the Alaska Marine Highway System ferries and for air routes into southeast Alaska. The ferries have been carrying passengers at maximum capacity, while airline passengers have increased by about 10 percent during this period. The number of visitors who arrive by cruise ships has steadily increased in recent years, from about 60,000 in 1977, to an estimated 82,000 in 1982 and 90,000 in 1983 (KGB 1983a).

Government is an important sector in the KGB. Most of the federal agencies are associated with the management of marine or forest resources or transportation. Nearly all of the major state agencies have offices in the KGB.

State funding accounts for 25 percent of the KGB's government budget and 35 percent of the City of Ketchikan's budget (KGB 1983a). Altogether, more than 45 percent of the KGB and the City governments' revenues are from state and federal sources (KGB 1983b). Government funding, primarily from the state, has also been a significant factor in financing construction projects in the local and regional impact areas.

Labor force, employment, and unemployment trends in the KGB are detailed in the studies by Entercom (1982a) and NISR (1983). Total employment increased by an annual average rate of 3.9, 3.1, and 3.2 percent during the 1960s, 1970 to 1975, and 1975 to 1980, respectively. Employment grew almost three times faster than the population during 1970-1980. The unemployment rates in the KGB have exceeded 12 percent since 1980. A decreased demand for forest products as a result of the world recession and a 1982 botulism incident, which decreased the demand for canned salmon (KGB 1983a), are contributing factors. The unemployment rate among Natives has been 2.4 times higher than for the KGB labor force. Even among Native people who were currently employed, they were much more likely to have been employed less than full-time and have been recently unemployed (Entercom 1982a).

The factors underlying the increased labor force participation rate may include social factors, such as the entry of increasing numbers of women into the labor force and of persons born in the post-war baby boom (Entercom 1982a). The industries that accounted for the largest number of new jobs were services; retail and wholesale trade; and transportation, utilities, and communications. The growth of tourism has contributed significantly to the number of new jobs created in the area.

Total wage and salary employment and the percentages of total employment for each industry for 1982-83 are presented in Table 3-16. The government sector made up the largest share of Ketchikan's wage and salary employment. The next largest employing sectors in descending order were services, retail trade, manufacturing, and transportation, utilities, and communications.

Large seasonal variations in employment are more pronounced in the KGB than in the Alaskan economy. Due to greater dependence on resource-based manufacturing, the average difference between summer and winter employment in the KGB is 28 percent. The forest product and fish processing industries are responsible for more than half of the quarterly employment variation. Construction employment is also highly seasonal, accounting for approximately 12 percent of the total seasonal change in employment (Entercom 1982a).

TABLE 3-16

WAGE AND SALARY EMPLOYMENT BY INDUSTRY
KETCHIKAN GATEWAY BOROUGH
1982, 3rd Quarter - 1983, 2nd Quarter

Industry	Covered Employment	Percent of Total
Agriculture, Forestry, and Fisheries 1/	12	0.2
Mining	ND	-
Construction	330	5.6
Manufacturing	949	16.0
Transportation, Communications, and Utilities	483	8.1
Wholesale Trade	148	2.5
Retail Trade	1,007	17.0
Financial, Insurance, and Real Estate	206	3.5
Services	1,052	17.7
Government	1,693	28.5
Federal	334	
State	545	
Local	814	
Miscellaneous	ND	-
TOTAL	5,937	99.1 2/

ND = not reported due to disclosure.

1/ Employers paying less than $20,000 per quarter in wages are not required to report number of employees.

2/ Mining and miscellaneous employment consists of 0.6 percent of total employment.

SOURCE: Alaska Department of Labor, Research and Analysis 1984.

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The ratio of nonbasic to basic employment, which is an indicator of the self-sufficiency of the local economy, was developed in the Entercom and NISR studies. The ratio has increased from about 0.6 in the early 1960s to about 1.0 to 1.1 in 1980, a pattern consistent with national trends.

Facilities and Services in the Local Impact Area

Facilities and services data (Entercom 1982a; NISR 1983) are summarized and updated below.

Housing:

The number, type, and general location of housing units in the KGB in 1981 is presented in Table 3-17. During the 1970s, the number of dwelling units in the borough increased by approximately 120 units per year, including about 70 single family homes per year (Entercom 1982a). The rate of new dwelling units has increased by 151, 200, and nearly 300 units in 1981, 1982, and 1983, respectively. The vacancy rate has been historically low due to the high degree of seasonality in the economy and the resultant reluctance of property owners to try to carry vacant property through the slack seasons. The vacancy rate has risen in recent years as new units have been added to the housing stock at the higher rate.

TABLE 3-17

HOUSING UNITS BY TYPE AND LOCATION, KGB
1981

Type of Housing Unit	City of Ketchikan		Remainder of Borough		KGB Total	
	number	percent	number	percent	number	percent
Single Family	1248	41	1006	60	2254	48
Multi-unit	1468	48	232	14	1700	36
Mobile Home	116	4	290	17	406	9
Other[1/]	199	7	150	9	349	7
TOTALS	3031	100	1678	100	4709	100

1/ Other includes boats, floathouses, hotels, rooming houses, cabins, and group living quarters.

SOURCE: Entercom 1982a.

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In 1981 it was found that the minimum sales price for a new, single family, two bedroom ranch style home with about 1,050 square feet was about $85,000. Sales were strongest in the $95,000 to $105,000 range. Starting prices for a small, two bedroom condominium, converted from an apartment, were about $45,000, while higher quality condos sold in the $75,000 to $80,000 range. Approximately 30 percent of housing units are rented. The average monthly rents were $400, $600, and $800 for one-, two- and three-bedroom apartments, respectively (Research Design Publication, Inc. 1983; NISR 1983).

During the first half of 1983 there were 5,540 lots in the borough, of which 32.7 percent were vacant. These vacant lots do not necessarily have road access or improvements. Although the total number of lots increased by almost 16 percent between 1978 and 1983, developed lots increased by almost 30 percent. There are 6,400 ac of private land, 24,000 ac of native lands, and 11,593 ac of borough lands in the Ketchikan Gateway Borough. Borough lands on the roaded system include 2,000 ac. The major limiting factor in developing land for residential use is the cost of site preparation and the installation of streets, sewer, water, and electricity.

Education:

Between the 1974-75 and 1981-82 school years, enrollment in the KGB School District followed the national trend as it declined by an average of 2 percent per year (Research Design Publication, Inc. 1983). Based on a January 1983 count, enrollment had increased by 1.8 percent from the 1982-83 enrollment (KGB Planning Department 1984). Table 3-18 displays the enrollment as of January 1983, optimum number of students, and capacities of each of the district's schools. Enrollment at one school was over capacity and enrollment at four schools exceeded the optimum. In early 1983, KGB voters approved a bond issue for $16.9 million to fund three projects: a new elementary facility located at North Point Higgins, expansion of facilities at Ketchikan High School, and expansion of Schoenbar Junior High School.

Transportation:

In 1983 there were an estimated 10,800 registered vehicles in the KGB, approximately 0.9 vehicles per person. The road system in the KGB consists of 85 mi of streets and highways on Revilla Island. The state maintains 54 mi, and the remainder is maintained by the City of Ketchikan and by private owners.

The main thoroughfare through the City of Ketchikan and the KGB is Tongass Avenue. In 1982 the design capacity of this road was exceeded from 7 to 8 hours per day in the downtown area (KGB 1983a). Parking is also a major problem that contributes to traffic congestion. A secondary corridor through the city is presently being considered, but because its alignment has been controversial, a final location has not yet been determined. Longer range proposals to remedy some of the

TABLE 3-18

ENROLLMENTS AND CAPACITIES, KGB SCHOOL DISTRICT
1983-1984

School (Grades)	Total Student Enrollment as of 1/84	Optimum	Capacity	Ratio of Student Enrollment to Capacity
Houghtaling (K-6)	536	450	525	1.02
Valley Park (K-6)	346	325	350	0.99
White Cliff (K-6)	381	375	400	0.95
Schoenbar (7-8)	396	380	400	0.99
Ketchikan (9-12)	715	800	1000	0.72
Revilla Alternative (9-12)	40	45	45	0.89
Subtotal	2414	2375	2720	0.89
Correspondence Study	103	95	120	0.86
Totals for All District Programs	2517	2370	2840	0.88

SOURCE: KGB Planning Department 1984.

traffic congestion include the Tongass Narrows Crossing, a public bus system, and parking facilities. The Tongass Narrows Crossing could provide access by highway to the Ketchikan International Airport on Gravina Island and access to Pennock Island where the terrain is amenable to residential development. The airport is presently reached by small car ferry. There is no public transportation to Pennock Island; the few residents use their own boats.

Medical Services:

Ketchikan General Hospital (KGH) is owned by the City of Ketchikan and leased for operation to Health and Hospital Services, Inc. of Bellevue, Washington. The staff consists of a radiologist, anesthesiologist, and 18 physicians who have a private practice in Ketchikan. These physicians take turns rotating on call for the emergency room. During the summer, the hospital contracts for emergency room physicians to handle the medical needs of the transient population and the community.

The 48-bed facility is the primary acute care hospital for the panhandle south of Petersburg, although Ketchikan residents comprise about 75 percent of the patient load. In addition, there are 44 licensed beds in the nursing home. The average daily census for adults and pediatrics in primary acute care for FY 1983 was 17.5 patients, reflecting an occupancy rate of 38 percent. The occupancy rate for newborns and the nursing home was 32 percent and 71 percent, respectively (Kleinbaum 1984). The hospital has the flexibility to shift beds in the nursing home to primary acute care if the need arises.

The physical therapy quarters, surgical area, central supply area, and nursing home underwent expansion and were completed in 1981. The administration is considering expansion of the laboratory and X-ray facilities and the administrative offices, which would be completed by 1991.

The Ketchikan Medical Clinic, Wilson Medical and Surgical Clinic, Ketchikan Public Health Clinic, and the Alaska Native Health Services are the four major clinics in the KGB. The Ketchikan Medical Clinic and the Wilson Clinic each have four physicians on staff. The Ketchikan Public Health Clinic has nurse practitioners on staff and provides health care at no cost. The Alaska Native Health Services clinic has four family practitioners and serves the Alaskan Native community. The State Pioneer Home, a 49-bed facility for senior citizens, opened in 1982.

Social Services:

A number of stressful factors found in Ketchikan make the residents susceptible to mental and social problems, including domestic violence, alcoholism, depression, crime, vandalism, and marital problems. The stressful factors contributing to these problems are the following: Ketchikan's physical isolation, heavy year-round rainfall, long dark winters, free time associated with seasonal employment and few developed indoor and outdoor recreational opportunities, cultural isolation for Native Americans, and the high cost of living.

The nonprofit social service agencies provide a wide range of services, including daycare, substance abuse counseling, educational and preventative care programs, employment counseling, and shelter and residential care. There are no social services located in Saxman, with the exception of a part-time aide hired by the Tlingit-Haida Central Council. A list of the social service groups is presented in Table 3-19.

TABLE 3-19

SOCIAL SERVICE AGENCIES

Department of Health and Social Services, Division of Public Assistance
Gateway Community Mental Health Center
Department of Health and Social Services, Division of Family and Youth Services
Ketchikan Association of Parents for People with Special Needs
Ketchikan Health Center
Southeast Alaska Health Systems Agency
Women in Safe Homes
Division of Social Services - (daycare)
Gateway Opportunity Center
Ketchikan Children's Home
State Juvenile Probation Office
Ketchikan Youth Services
Alaska Legal Services
Alcoholics Victorious

In addition to these nonprofit agencies, limited social services are provided through the private sector. A psychiatrist and a psychologist have an established full-time practice in Ketchikan.

The current capacity of agencies to accommodate the demand for services varies by agency. The limitations agencies face in meeting the demand are understaffing, crowded facilities, and unreliable sources of funding. For most of the agencies, the demand has reached or exceeded the capacity to deliver services, particularly with regard to staff levels. Recent cutbacks in budgets have been experienced by virtually all of the agencies.

Local Government and Fiscal Conditions in the Local Impact Area

The City of Ketchikan is a Home Rule City governed by a seven-member council and mayor and administered by a city manager. As a home rule city within a second class borough, the city has all the powers not prohibited by law or charter except for those mandated to or assumed by the KGB. The city provides public safety, water and sewer service, refuse collection, fire prevention, police protection, harbors, mental health, and road maintenance within the city limits. In addition, the city provides telephone and electrical service borough-wide. A number of its other facilities and services such as libraries, museums, solid waste disposal, mental health, substance abuse programs, and parks and recreation are available to residents both inside and outside of the city. These city facilities are financed, in part, through city property taxes.

Assessed valuation in the city grew at an annual average rate of 14 percent between 1976 and 1982. The city mill rate in 1982 was 5.8 per $1,000 of assessed valuation, down from its average during the 1976 to 1980 period of around 11 mills due to high levels of state revenue sharing (U.S. Borax 1983a). The City of Ketchikan levies a 2.5 percent sales tax and, combined with the 1.5 percent borough tax rate, the city pays a 4 percent sales tax. Sales tax revenue increased by 12 percent annually between 1973 and 1982. Sales tax revenues accounted for 11 percent of the total municipal revenues in 1980. The ratio of debt service to general expenditures declined from 1975 (0.08) to 1983 (0.03) but jumped to 0.10 with passage of the local bond issue to finance a new elementary school (Ketchikan Gateway Borough 1985).

The Ketchikan Gateway Borough is governed by a seven-member assembly and mayor and is administered by a borough manager. The borough provides a framework for assessment and collection of taxes, planning, platting, zoning, and animal control. The Ketchikan Gateway Borough School District is governed by an independently elected school board. The borough oversees the school district's budget, and funds come primarily from the local and state governments. The KGB operates the Ketchikan International Airport.

The greatest percentage of borough revenues come from state sources in the form of municipal assistance and state revenue sharing. Assessed valuation for the borough (including the city) increased from $214 million in 1976 to $533 million in 1982, an annual average increase of 16 percent. The KGB's mill rate has steadily declined since 1976, when it was 9.6, to the 1982 rate of 1 mill, due to increased intergovernmental transfers. Sales tax revenue is the second largest contributor to overall revenue. Purchases outside of the city are taxed at 1.5 percent. Between 1973 and 1982 sales tax revenues in the KGB increased at an annual average rate of 12 percent. Total sales taxes collected in the KGB (including the city) in 1982 were $3.5 million. The KGB's debt service to expenditures ratio was 0.04 in 1981 (U.S. Borax 1983a).

The City of Saxman is a Second Class City governed by a seven-member council which includes the mayor and administered by a city administrator. Approximately 90 percent of the city's residents are Native American. Unemployment is notably greater and per capita income notably less than for the Ketchikan Gateway Borough as a whole; housing is limited, and per-household occupancy is notably higher than that for the borough as a whole. The city provides water and sewer, road maintenance, public safety, and fire protection services and is engaged in numerous economic, infrastructure, and cultural development projects. The city owns and operates the Saxman Seaport, and is also the site of a proposed 300-berth small boat harbor. There is currently no property, sales, or other taxation. Approximately 75 percent of overall city revenues are derived from a variety of state sources, and the remainder from the operations of the seaport, water and sewer user fees, and other local and regional sources. The offices of Cape Fox

Corporation, the Native corporation for the area created by the Alaska Native Claims Settlement Act, are located within the city. The tribal governing body is the Organized Village of Saxman, created by the federal Indian Reorganization Act of 1934-36.

3.3.2 State and National Economics

The State Economic Environment

Since 1975, Alaska's population and economy have expanded rapidly, first under the influence of Trans-Alaska Pipeline construction, and later under the stimulus of state spending of oil revenues. Between 1975 and 1982 population grew at a compound annual rate of 2.6 percent (Alaska Department of Labor 1982). Nonagricultural employment has also grown rapidly, at an annual compound rate of 3.0 percent (Alaska Office of Management and Budget 1983), but most of this employment growth has not been in basic industry or state government, but rather in local government, general construction, trade, transportation and communications, and services (ISER 1983a).

The result has been a substantial reduction in the cost of doing business and (relative to the nation) the cost of living, and a substantial improvement in living conditions (ISER 1983b). Recent studies, however, suggest that about 95 percent of the employment growth and 91 percent of the growth in personal income since 1978 have been the result of state spending, suggesting that the current economic growth may be vulnerable to declines in state spending (Alaska Department of Labor 1983b; Erickson and Associates 1982).

The State Fiscal Environment

The dynamics of state government spending in Alaska differ substantially from other states, and many experts feel that they are not well understood. Although population has grown rapidly, state spending has far outstripped that growth. Since fiscal 1978, the inflation-adjusted state budget has grown at a compound annual rate of 14.2 percent (Legislative Finance 1982). Actual state spending, including borrowed money and other "off budget" items grew even faster (Erickson and Associates 1982). The growth of in state spending was related to the growth of state petroleum revenue, which rose from $49 million to $3,575 million over the FY 1973-1982 period (Alaska Department of Revenue 1983a).

The rapid growth of oil revenue received by Alaska since 1979 appears to have affected the state's fiscal environment in five separate ways:

- o The flow of oil revenue has been used to finance increased public capital formation, services, amd subsidies in the areas of housing, industrial development, and energy.

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- o Taxes paid by households and fees paid by nonpetroleum businesses have been reduced.
- o The state has established and deposited substantial sums in a constitutionally protected public "savings" account, the Alaska Permanent Fund.
- o Public sector borrowing, both by the state and its instrumentalities, has increased.
- o The state has made direct per capita payments to its residents.

Offical state forecasts suggest that real (inflation adjusted) state oil revenues will fall 12.8 percent in fiscal 1984, at an average annual rate of 4.7 percent in the FY 1985-90 period, and then at a 12.1 percent annual rate through 1999 (Alaska Department of Revenue 1983). While this is the projection the state uses for budgeting purposes, it is only one of numerous alternative "official" scenarios. Revenues are expected to be influenced by world oil prices, production decline rates in existing fields (mainly Prudhoe Bay), and new oil field development. Although much uncertainty exists concerning oil prices and new oil field development, most experts believe that Alaska's oil revenue peaked in fiscal 1982, and that it will fall in the future, necessitating major fiscal and economic adjustments for the state (ISER 1983c).

<u>The Economic Environment in Alaska for Metals Mining</u>

The state's taxes on metal mining, though by no means the lowest in the nation, are relatively favorable to such ventures (Whitney and Whitney, Inc. 1982). Major state and local taxes that would affect large scale metals mining in Alaska are local property taxes, the mining license tax, and the corporate income tax.

Although there is no statewide property tax in Alaska, local governments are allowed to impose such taxes at a rate not to exceed 3 percent annually on the "full and true value." The tax on nonproducing mining claims is limited to $200 for each 20 ac or fraction of 20 ac, but the full value of the mineral interest in a mining property as well as the value of improvements would presumably be taxable as long as production occurs. Mining properties outside the boundaries of any local government are not subject to any property tax (Alaska Department of Community and Regional Affairs 1982).

Alaska's mining license tax is a net proceeds tax based on the net income attributable to the property after deduction of operating costs, royalties, depletion (at 15 percent of gross income), and most taxes other than the federal income tax. The deduction for depletion may not exceed 50 percent of the property's net income before depletion. The

tax rate is based on a sliding scale, but all net income over $100,000 per year is taxed at 7 percent. New mines are exempt from the tax during the first three and one-half years after production begins (Alaska Statutes 43.65).

The state corporate income tax as applied to mining operations is an "apportioned" tax. Under this type of tax a firm's worldwide net income is apportioned to the various jurisdictions in which it does business in accordance with an established formula based on sales, property value, and salaries. The maximum tax rate, applying to all taxable income over $4 million annually, is 9.4 percent. Allowable deductions generally follow the federal tax code, though some recently instituted federal deductions and credits are not allowed (Alaska Statutes 43.20).

Despite the relatively favorable state tax climate, mining operations in Alaska will generally be subject to cost penalties associated with long distance from markets, remote locations, and generally high unit costs of labor and other inputs. As a result of these and other factors, there are no large scale metallic mineral mines now operating in the state. Mineral exploration expenditures rose rapidly in the 1970s, reaching a peak in 1981. Since then they have declined under the influence of adverse market conditions. The total value of nonprecious, nonfuel mineral production in Alaska in 1982 was $1.6 million (Alaska Department of Natural Resources 1983).

The Market Environment for Molybdenum

Even more than most other mineral commodities, molybdenum has recently been subject to depressed market conditions. U.S. production, which had been growing annually at a relatively steady 6-7 percent during the 1962-1980 period (Bureau of Mines 1981), declined 7 percent in 1981, and fell 46 percent in 1982. Employment in mines producing molybdenum as their main product (accounting for approximately 70 percent of 1980 production) fell from 5,500 in 1981, to an estimated 1,500 in 1982 (Bureau of Mines 1983). Widespread mine closures in late 1982 and early 1983 have probably resulted in further loss of employment and additional declines in production in 1983 (Mining Journal 1983). However, the two major molybdenum mines in Colorado (Henderson and Climax) have reopened.

The U.S. has historically been the world's leading producer of molybdenum, with U.S. exports exceeding the total output of Chile, the next largest producer. In 1982, however, Chilean production (almost all of which is exported) reached 46 million pounds, marginally exceeding U.S. exports. Because exports have declined more slowly than domestic production and consumption, they have become relatively more significant to the U.S. industry. Net exports as a percentage of domestic production grew from 36 percent in 1981 to 55 percent in 1982 (Bureau of Mines 1983).

The real price of molybdenum, which had remained relatively steady in the $4-6 per pound range (measured in 1982 dollars) from 1940 to 1975, increased rapidly thereafter, reaching an all time high in 1979 of over $22 per pound (1982 dollars) in dealer quotes. The dramatic rise was associated with the following: (1) labor disputes and other factors that temporarily constrained supply, and (2) the increased investment in energy facilities, which tend to use large quantities of molybdenum-containing steel. Since 1980, real prices have fallen back to their historic level (Appendix J, Figure 6).

In 1982, 85 percent of molybdenum consumption in the noncommunist world was associated with the production of steel and other ferrous metal products, particularly for transportation, energy, and construction applications (Mining Journal 1982). The worldwide recession of the early 1980s had an especially severe effect on these industrial sectors, and the decline in oil prices exacerbated economic distress in the energy area.

Historically, U.S. molybdenum production has been dominated by a few large mines operated by a very small number of large firms. Other production has generally been a by-product of copper or other metal smelting activities. In 1982, 14 separate firms produced molybdenum in the U.S., but 92 percent of that production was accounted for by only 4 firms (Bureau of Mines 1983).

3.3.3 Cultural Resources

Potentially significant cultural resources identified or reported in the project area are all located on or near the coast. They include a number of reported smokehouses and several historic cabin ruins (Appendix K, Table 1). Coastal portions of the project area also have some potential for early prehistoric sites. This potential is reduced in inland mountain valleys, which have undergone more recent glaciation, but ethnographic data indicate that the interior mountain valleys and moderate mountain slopes may contain cultural resources of late prehistoric and early historic age.

Until recently, there has been little archeological research in southern southeast Alaska and the prehistory of the area remains unknown. At least two sites dating to the early postglacial period (ca. 8,000 to 10,000 years ago) have been excavated in northern southeast Alaska (Ackerman 1974, 1980; Davis 1980), and there is clear potential for sites of similar antiquity in the general project area. Due to such phenomena as isostatic rebound of the land mass, fluctuating sea levels, and the building of river deltas in the postglacial period, early sites once located on the coast could now be up to 500 ft above sea level and a half mile or more inland in some areas (Twenhofel 1952; Roberts 1982; de Laguna 1960).

Historically, two Native peoples, the Tsetsaut, or Wetalth Athabaskans, and the Sanyakwan, or Cape Fox Tlingit, are known to have inhabited the project area (Campbell 1980, 1981; Emmons 1911; Duff 1981; Hodge 1913; Goldschmidt and Haas 1946). The Tsetsaut were an inland oriented people who followed a seasonal round that took them from fish streams in the spring and summer, to the mountains for hunting in late summer and fall, and to the mountain valleys for winter hunting. They apparently had no permanent villages, but returned repeatedly to favored campsites (Campbell 1981; Duff 1981). The Sanyakwan, by contrast, were coastally oriented, residing in several permanent villages, but seasonally occupying fish camps on salmon streams. Their hunting and trapping activities were also concentrated along the coast (Campbell 1980; Goldschmidt and Haas 1946). Around 1835 a blood feud began between the two peoples, which caused the Tsetsaut to move to the Portland Canal area and led to their near extinction by 1885 (Campbell 1981; Hodge 1913; Duff 1981). The Sanyakwan continued to fish, hunt, and trap in the current project area into the twentieth century (Goldschmidt and Haas 1946).

Information on EuroAmerican use of the project area is confined to the twentieth century. Intermittent hunting and trapping have occurred here since early in this century. Hand logging of the shores of Wilson Arm/Smeaton Bay and Boca de Quadra had begun by the mid-1920s and persisted until at least 1947 (Jackson 1974). The whole region has been prospected for various minerals since the late 1890s, but no significant finds were reported in the project area until recently (Brooks 1902; Wright and Wright 1908; Wolff and Heiner 1971).

While there is moderate to high potential for cultural resources in some parts of the project area, documented resources are few, in part because of lack of research. The earliest report of cultural remains comes from George Vancouver (1801), who discovered a Native burial box and the remains of a few "huts" in Smeaton Bay in 1793, possibly near the head of Wilson Arm (Ackerman and Gallison 1981). An unconfirmed burial site at the confluence of the Wilson and Blossom rivers, reported by the Sealaska Corporation staff, may refer to this same site (ERTEC 1982). Goldschmidt and Haas (1946), who interviewed informants to document Native traditional land use, reported two smokehouses at the head of Smeaton Bay (Wilson Arm) and one near the head of Boca de Quadra, apparently at the mouth of Aronitz Creek. The smokehouses reported at the head of Wilson Arm may correspond to the site of six smokehouses at the confluence of the Wilson and Blossom rivers reported by Ackerman and Gallison in 1980. None of these locations have been confirmed archeologically, but all could potentially be significant if located.

Two archeological surveys have been conducted specifically for this project. Ackerman and Gallison (1981) conducted reconnaissance level surveys by boat and on foot along the shores of Wilson Arm, Bakewell Arm, upper Boca de Quadra, and the lower Wilson and Blossom rivers, and

by helicopter over the mountainous interior between Wilson Arm and Boca de Quadra. They located 21 sites in all, 5 of them modern and in current use, 11 modern abandoned, and 5 of historic age, which warranted shovel testing for earlier components. All of the latter were in the river estuary and coastal zone. A second survey, consisting of systematic shovel testing of the access road corridor from Wilson Arm to Quartz Hill and of proposed locations of associated facilities, was conducted (ERTEC 1982). No new cultural resources were identified, but 2 historic sites and 1 modern abandoned site previously identified by Ackerman and Gallison were tested. No earlier components were detected there.

3.3.4 Land Use

This discussion is limited to land use within Misty Fiords National Monument. Factors pertaining to land use conditions within the Ketchikan Gateway Borough were previously described within the socioeconomics discussion (Section 3.3.1).

Misty Fiords National Monument is a conservation unit of 2,294,343 ac established in 1980 by ANILCA within the existing Tongass National Forest (see Figure 3-42). The Monument constitutes one of four ranger districts within the Ketchikan Area, which is the southernmost of the three management areas that comprise the Tongass National Forest. In area, Misty Fiords National Monument represents approximately 44 percent of the Ketchikan area, and 14 percent of the entire forest (Forest Service 1982b).

The federal government is the dominant landowner in southeast Alaska and the Ketchikan Area, although the land selection and transfer process is changing somewhat the distribution of ownership. Federal ownership is nearly 100 percent within the Monument, but there are 560 ac of private inholdings in addition to the claims around Quartz Hill held by Pacific Coast Molybdenum Company. Three-quarters of these other private lands are located at the mouth of the Unuk River at the northern end of the Monument (Forest Service 1982c, p. 37). A 5 ac private homestead with an abandoned cabin is located at the mouth of the Tombstone River (Rainey 1984). The mining claims held by Pacific Coast Molybdenum Company, which cover 647 ac and have become private property through patenting, and also unpatented mining claims, cover a total area of approximately 4,900 ac near the center of the Monument.

Approximately 1,000 additional mining claims are located elsewhere within the Monument, and are subject to the claim validity determination process (Forest Service 1982c, p. 22). The State of Alaska also has an ownership role through its jurisdiction over tidelands and nearshore marine waters. The state and the Forest Service are currently litigating selection by the state of a parcel at Manzanita Bay for development of a state marine park (Barber 1983a).

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

MISTY FIORDS NATIONAL
MONUMENT / WILDERNESS

SOURCE FOREST SERVICE DATE APR 84

FIGURE 3-42

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

Existing land use development is limited to facilities located on the above private lands, cabins and trails constructed by the Forest Service, and a few private recreation sites located on Forest Service lands. The existing Quartz Hill project facilities represent by far the greatest level and extent of development. Three small commercial recreation facilities are located within the Monument, including resorts on private lands on the Chickamin River and Hidden Inlet and one operation at Humpback Lake under special use permit (Hamberg 1983; Forest Service 1982c, pp. 30, 37). Forest Service development for recreation is scattered throughout the west-central sector of the Monument, on either side of Behm Canal from Walker Cove south to the Humpback Lake area. This development consists of 15 cabins, 3 shelters, and 13 trails covering approximately 25 mi total (Hamberg 1983; Forest Service 1982c). The only other reported facilities within the Monument are an abandoned fish hatchery at Hugh Smith Lake and the Bakewell Creek fishway, which is currently being rehabilitated.

Basic management direction for the Monument is provided by ANILCA and the Wilderness Act of 1964 (16 USC 1131-1132), through the former's designation of 93 percent of the Monument as wilderness. Wilderness values, attributes, and management objectives are addressed in the following section, and were also reported at some length in the Road Access and Bulk Sampling EIS (Forest Service 1982a, pp. 3-41 to 3-43), and are incorporated here by reference. Aside from legislation, management derives from Interim Management Guidelines (Forest Service 1982c) developed for the Monument in 1982 and the Tongass Land Management Plan (Forest Service 1979). The Misty Fiords District is currently developing a management plan for the Monument, with a draft environmental assessment of the proposed management plan expected to be released in 1986 (Barber 1983a). The wilderness portion of the Monument is and will continue to be managed to preserve wilderness resources and provide a wilderness recreation experience. The standard wilderness management regime has been amended by ANILCA, however, to provide for traditional motorboat and plane access, subsistence use, public use cabins, and similar conditions prevalent in Alaska.

Management policy for the 152,610 ac, nonwilderness area around Quartz Hill is clearly different from that for the surrounding wilderness area. Surface occupancy and access to the U.S. Borax claims has already been provided, as prescribed by ANILCA, and project activities have been the dominant use of the nonwilderness area for the past several years. While the nonwilderness area has essentially been managed for mining activity, it is not a multiple use area. These lands are to be managed to protect ecological, cultural, geological, historical, or scientific values, and are not open to commercial timber harvesting (Forest Service 1982b). Nonwilderness national monument lands are also withdrawn from further mineral entry, although ANILCA permits further exploration and prospecting on lands within three-quarters of a mile of valid claims.

3.3.5 Wilderness

Most of Misty Fiords National Monument was designated as wilderness, to be managed according to the applicable provisions of the Wilderness Act, by ANILCA in 1980. The approximately 2.1 million ac of wilderness within the Monument represents 94 percent of all wilderness acreage in the Ketchikan area, and 39 percent of all wilderness acreage on the entire Tongass National Forest (Forest Service 1982b). Other wilderness areas near Ketchikan are the South Prince of Wales Wilderness and the small Coronation, Warren, and Maurelle Islands wildernesses. Large wildernesses in the Stikine and Chatham areas include the South Baranof, Stikine-LeConte, Tracy Arm-Fords Terror, Admiralty Island, West Chichagoff-Yakobi, and Endicott River areas.

Wilderness management is necessarily restrictive of human activities. As defined by Section 2(c) of the Wilderness Act:

> A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Administrative provisions of the Wilderness Act require that these lands be left unimpaired for future use and enjoyment as wilderness, that their wilderness character be preserved (Section 2[a]), and that wilderness areas shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation, and historical use. In Forest Service implementation of these provisions, public uses dependent upon a wilderness setting are subordinate to wilderness values and resources in cases of conflict (Forest Service Manual 2320.2); the primary objectives of Forest Service wilderness management are to maintain high quality wilderness and perpetuate the wilderness resource.

Management of the Misty Fiords National Monument Wilderness follows these general principles, plus specific provisions of ANILCA and Forest Service plans. The Wilderness Act permits aircraft and motorboat use in areas where it is already established, and ANILCA specifically allows such motorized activity and other established uses such as sport hunting and public recreation cabins. More detailed administrative direction for the Monument and its wilderness area will be provided by the forthcoming management plan.

The wilderness resources and values that are to be protected are more difficult to characterize than more tangible resources such as vegetation or wildlife. Historically, the values of wilderness were generally recognized as experiential (e.g., nature appreciation, freedom, solitude, spiritual dimensions), mental and moral restoration, and scientific contributions (Hendee et al. 1978, pp. 11-15). These value themes emphasize the benefits wilderness provides to people, but wilderness values clearly extend well beyond recreation. The values recognized by Section 2(c) of the Wilderness Act were expanded by the Forest Service to characterize wilderness attributes during the second Roadless Area Review and Evaluation (RARE II) process, and provide a suitable framework for analyzing the wilderness values of Misty Fiords National Monument. Specifically, the RARE II process recognized that wilderness attributes included natural integrity, apparent naturalness, opportunities for solitude, opportunities for primitive recreation, and supplemental attributes such as ecological, geological, scenic, and cultural values (Forest Service 1977c). These wilderness value components and their relation to the Misty Fiords wilderness are described below in more detail.

1. Natural Integrity. Natural integrity is "the extent to which long-term ecological processes are intact and operating" (Forest Service 1977c, p. 12). Areas that possess this attribute have been minimally subjected to vegetative manipulation, the impacts of facilities, or other disturbances of natural processes. The Misty Fiords wilderness is essentially untouched (Forest Service 1982c, p. 27) and has a high degree of natural integrity, with only small areas showing effects of hand logging and various types of low-intensity development for recreation or fisheries management.

2. Apparent Naturalness. This attribute is closely related to natural integrity, but the evaluation of apparent naturalness emphasizes perceived naturalness and the importance to visitors of disturbances of natural processes (Forest Service 1977c, p. 13A). Most visitors to Misty Fiords no doubt view the area as very natural in appearance.

3. Opportunities for Solitude. Because the perception of solitude varies between individuals, evaluation of opportunities for solitude depends largely upon physical factors such as absolute size and the presence of vegetative or topographic screening (Forest Service 1977c, p. 27). On balance, Misty Fiords provides outstanding opportunities for solitude. The area is very large in size, and the forest vegetation and rugged topography can very effectively screen visitors from sights or sounds of other visitors. These same factors can also serve to concentrate use, however, as steep slopes and nearly impenetrable vegetation confine most use to the shoreline, air-accessible lakes, and trails. To date, these conditions have not greatly affected opportunities for solitude, because use is low even in the most popular sites and most areas of the Monument are rarely visited. Off-site intrusions from aircraft or nearby development are also generally low, with a few exceptions such as the flight seeing routes. In 1984 approximately 2,000 flights occurred over Wilson Lake, Big Goat Lake, and Rudyerd Bay (Barber 1983a).

4. Opportunities for Primitive Recreation. These opportunities primarily relate to recreation activities that require a wilderness setting, and their evaluation overlaps somewhat with treatment of solitude and other attributes (Forest Service 1977c, p. 34). A major additional component of this attribute is the presence of physical diversity (such as varied vegetation, terrain, and climate), challenge or risk (such as weather disturbances, dangerous animals, and difficult terrain features), and the absence of man-made facilities. Misty Fiords generally rates very high in regard to opportunities for primitive recreation. The Monument offers a great deal of diversity, as it includes nearly all major geological and ecological characteristics found in southeast Alaska (Forest Service 1982c, pp. 3-4). Many types of terrain, vegetation, water bodies, and wildlife are present, as are the complete range of climates. Risk and challenge are present in the form of adverse weather, glaciers, dangerous animals, and avalanche potential. The presence of cabins, shelters, and other facilities detracts slightly from primitive recreation opportunities. However, these facilities and the few trails in the Monument are not built to a high standard of development, they are small in number and scattered, and they are perceived by users as natural components of primitive recreation due largely to the weather and wildlife.

5. Supplemental Attributes. The supplemental wilderness attributes are generally the wilderness values that are not directly related to human use benefits. The Wilderness Act implies that ecological, geological, scenic, or cultural

features enhance (but do not define) wilderness quality if they occur to an "extraordinary" degree (Forest Service 1977c, p. 41). Due to the diversity and productivity of its aquatic and terrestrial resources, as described in Section 3.2, Misty Fiords National Monument possesses high ecological values. An additional specific ecological value is represented by the Red River Research Natural Area, an 8,000 ac area near Marten Arm of Boca de Quadra set aside in 1980 to reserve a significant stand of Pacific silver fir (Forest Service 1982c, p. 27). Features of geologic interest include the fjords, sea cliffs, and glaciers, plus the solidified lava plug in Behm Canal that comprises the New Eddystone Rock Geological Area (Forest Service 1982c, pp. 3, 27). Scenic values are generally high (see Section 3.3.7), particularly in the former Walker Cove-Rudyerd Bay Scenic Area, and the potential for cultural resources discoveries appears to be significant (Forest Service 1982c, p. 24). The ecological, geological, and cultural features of the Monument, combined with the resource protection given by the Monument and wilderness designation, provide excellent opportunities for research that constitute substantial scientific values. Overall, Misty Fiords National Monument possesses high wilderness values within the supplemental attribute category.

3.3.6 Recreation

Recreational use of Misty Fiords National Monument is difficult to monitor due to vast size, low staffing levels, and an essentially infinite number of entry points. Contact with visitor industry sources in Ketchikan provides reasonably reliable data for certain types of use, but estimates for most types of use must be based upon intermittent observation, staff familiarity with the area, and professional judgment. The primary source of data on recreational activity is the Recreation Information Management (RIM) system maintained by the Forest Service. Data for the FY 1983 recreation season are reported where possible. These data are supplemented by additional Forest Service material and information obtained from two recent surveys, the interagency Alaska Public Survey (APS) and the Entercom survey of the Ketchikan area, to characterize use of the Monument and place this use in a local and regional perspective.

Additional data and descriptions of the characteristics, strengths, and limitations of these data sources are provided in Appendix L.

Despite its attractiveness, current use of Misty Fiords is low in comparison with many other national forest units or wilderness areas, particularly those in the contiguous 48 states. This is primarily due to limited access to and within the Monument, a cool and very wet climate, and a small regional population. Most users reach the Monument by ship or boat, but use by small private craft is particularly sensitive to weather, distance, and the lack of boat

service facilities between Ketchikan and the Monument. Aside from Ketchikan, the nearest fuel and servicing are located at Yes Bay on Cleveland Peninsula, off the northern tip of Revillagigedo Island. Air access is a frequent mode of access, but has become increasingly expensive in recent years. Travel within the Monument is also limited, as there are few trails and the terrain and vegetation make off-trail travel difficult or impossible in most areas. Consequently, virtually all surface activity occurs on or near saltwater or at plane-accessible lakes.

Aggregate estimated annual use of the Monument in FY 1983 was 77,500 recreation visitor days (RVDs) (Barber 1984a). These figures include viewing and other activities by passengers on the Alaska Marine Highway System during the time when ferries are offshore from the Monument; ferry data are added to the locally reported data by the Regional Office in Juneau. The Monument staff reported 41,560 RVDs of use for FY 1983 (Barber 1984a), 41,400 RVDs for FY 1982, and 39,000 RVDs for FY 1981 (Mullins 1983). Unless otherwise noted, subsequent citations of total use refer to figures reported by Monument staff, and exclude the indirect use by ferry passengers.

Use of Misty Fiords has been significantly higher since 1981, due to increased publicity and awareness resulting from the designation of the Monument and higher out-of-state visitation to southeast Alaska (Mullins 1983; Russell 1983). Nonlocal visitation by cruise ship, tour boat, and flightseeing services essentially did not exist prior to designation of the Monument in 1980 (Forest Service 1982a, p. 3-48).

Adequate time series data for overall use of the Monument do not exist, but figures on Forest Service cabin use and cruise ship visitation to Ketchikan provide some indication of recent trends. Use of the public recreation cabins within the Monument increased by approximately 54 percent from 1972 to 1983 (Forest Service 1983a; Barber 1983b), representing average annual growth of about 4 percent over this period. This is primarily an indicator of local (Ketchikan) use, as approximately 75 percent of all cabin use is currently by local residents. Cruise ship traffic, which accounts for virtually all flightseeing visitors to Misty Fiords, has steadily increased in the past four years. A total of 12 separate vessels carrying 90,000 passengers made 156 calls in Ketchikan during the 1983 cruise season, compared to corresponding figures of 6 ships, 46,000 passengers, and 87 calls during 1979 (Rice 1983). The passenger growth corresponds to an average annual rate of over 18 percent, although the increases for 1982 and 1983 were lower due to recessionary effects.

Visitation (the number of users) and visitor use (the aggregate time spent by these users) in the Monument exhibit very different patterns. Cruise ship, tour boat, and flightseeing passengers, virtually all of whom are out-of-state residents, comprise one of three major user groups. This user group accounted for an estimated 28,200 visits and 9,800 RVDs of use in 1983 (see Table L-2), indicating an average visit

of 4 hours (Barber 1984b). The second major user group consists primarily of local users, and includes private boaters, cabin users, resort visitors, and dispersed hunters and anglers (i.e., those not linked with cabin visits). These visitors have a much longer average length of stay, with an estimated 5,500 visits in 1983 generating nearly 23,700 RVDs of use; this represents an average visit of almost 52 hours.

Recreationists who visit the Monument for business purposes constitute a third major user group. This category of users includes U.S. Borax workers, Forest Service employees, and researchers or project workers from the Alaska Department of Fish and Game, the Southern Southeast Regional Aquaculture Association, or other organizations. Total business related recreational activity in 1983 was estimated at approximately 5,700 visits and 8,100 RVDs of use (Barber 1984); many of these visits are long-term stays, such as U.S. Borax assignments to the Quartz Hill camp. Quartz Hill workers accounted for about 3,100 of these RVDs, and much of the research activity in Misty Fiords is also related to the project.

Both visitation and use are highly concentrated in the area around Rudyerd Bay and Walker Cove, which extends to within approximately 8 to 10 mi of Quartz Hill (Figure 1-1). Cruise ship visits to this area involve one large vessel in the 700-passenger class and a smaller vessel carrying 60 to 90 passengers (Hamberg 1983, p. 10). Tour boats from Ketchikan spend about 4 hours each trip within Rudyerd Bay, while the standard flightseeing path is over Rudyerd Bay and the surrounding area. Of the 14 standard cabins within the Monument, 6 are situated on lakes that are between Rudyerd Bay and the Quartz Hill area, another is at Bakewell Lake, and 4 others are in the Manzanita-Ella Lake area just across Behm Canal to the west. Fly-in fishing and hunting also occur at or near many of the lakes in the west-central portion of the Monument. Private boating is the most widely distributed use, although Rudyerd Bay and Walker Cover are also the most popular boating destinations.

The central area of the Monument, which includes the Rudyerd Bay-Walker Cove area plus the Manzanita-Ella Lake area west of Behm Canal, received an estimated 65 percent of total 1983 use, equivalent to about 27,000 RVDs (Mullins 1983). The Smeaton Bay/lower Behm Canal unit accounted for about 15 percent of all use, followed by 12 percent for North Behm Canal, 5 percent for Boca de Quadra, and 3 percent for Portland Canal.

The Misty Fiords District accounts for approximately 15 to 20 percent of all use within the Ketchikan Area (Forest Service 1983b). Misty Fiords has a slightly higher share of local developed use relative to the other districts, despite being the only district with no roads and no resident population (other than the project camp). This is largely due to the cabin use pattern, as the cabins now located within the Monument accounted for approximately 27 percent of all cabin use within the Ketchikan area from 1972 to 1982 (Forest Service 1983a).

Recreation in Misty Fiords has greater local significance when viewed in the context of wilderness recreation. The only other wilderness within the Ketchikan area consists of the South Prince of Wales Wilderness and three small island wildernesses located off the northwest coast of Prince of Wales Island. Approximately 85 to 90 percent of all wilderness use in the Ketchikan Area in 1981 and 1982 occurred in Misty Fiords (Forest Service 1983b), and some types of wilderness use occur only in the Monument. No recreation cabins are located within the other Ketchikan Area wildernesses, for example, while Misty Fiords also includes the only wilderness trails and resorts in the management area. While wilderness type experiences are now rather readily available outside of designated wilderness areas, the wilderness use dominance of the Monument will increase as planned development reduces the availability of these opportunities.

Survey responses provide further indication of the local importance of the Monument. In the 1979 Alaska Public Survey, 81 percent of all respondents indicating use of Misty Fiords had Ketchikan addresses; of five other large wilderness areas in southeast Alaska, South Baranof was the only area receiving more than 1 percent of total use from Ketchikan residents (Clark 1981, Table B). Of all APS respondents from Ketchikan, 14 percent indicated that they had visited the Monument in the previous year (Clark and McGowan 1983). In the Entercom survey of the Ketchikan area, a minimum of 12 percent of all respondents reported boating (the most popular recreational activity included in the question) within the Monument during the year prior to the survey (Entercom 1982b, p. 171).

On a regional basis, wilderness use levels appear to be heavily influenced by population/distance relationships. Because Juneau is the largest population center, Juneau APS respondents represented a significant share of users for all six major wilderness areas (Admiralty Island, Glacier Bay, Misty Fiords, South Baranof, Stikine-LeConte, and West Chichagoff) studied by Clark (1981, Table B), ranging from 11.6 percent of all southeast Alaska users of Misty Fiords to 80.1 percent for Admiralty Island. Overall, 4.5 percent of all southeast Alaska respondents reported trips to Misty Fiords in the year prior to the survey. This was second to the 9.4 percent of all respondents who reported using Admiralty Island, and exceeded the figure of 3.7 percent for Glacier Bay.

3.3.7 Aesthetics

The Forest Service Visual Resource Management (VRM) System provides a methodology for evaluating the visual resources of an area. The following discussion is based on the Forest Service's application of the VRM system to the Misty Fiords National Monument and the nonwilderness monument area centrally located within Misty Fiords. In this system, the scenic quality of a landscape is evaluated according

to the degree of diversity of its various components, which are landform, rockform, vegetation, and water features (Forest Service 1974). Variety classifications, ratings for degree of diversity of physical landscape features, include A (distinctive), B (common), and C (minimal). A character type, which is a discrete geological land unit having distinguishing visual characteristics, provides a frame of reference for evaluating landscape features.

Visual Character of Misty Fiords National Monument

The Misty Fiords National Monument is located almost entirely within the Coast Range, which extends over much of southeast Alaska and includes a variety of geologic features: massive rugged landforms with elevations ranging from 4,000 to 8,000 ft, long meandering river systems, numerous fjords, and extensive areas of bare rock and ice.

The Rudyerd Bay and Walker Cove areas north of the Quartz Hill project are recognized for their distinctive geologic features. Between Rudyerd Bay and the project area are a number of large freshwater lakes (e.g., Wilson Lake, Big Goat Lake, and Little Goat Lake). Alpine lakes such as Big Goat Lake and Little Goat Lake offer exceptional scenic views.

The Misty Fiords National Monument is characterized by coniferous forest-covered mountain slopes, deciduous tree cover in the upper river drainages, and a variety of alpine ecosystems at higher elevations. Some landscapes in the Monument, such as from Tombstone Bay to Red Creek Pass, have variety class A (distinctive) scenic quality ratings. The Quartz Hill project area is characterized by variety class B (common).

Nonwilderness Monument Area

The nonwilderness area is located at the head of the Wilson Arm/Smeaton Bay and Boca de Quadra fjords. These long, narrow fjords, the major landscape features of this area, create contrasting spatial features among the surrounding rugged terrain. They have been classified as average in landscape diversity relative to the entire Coast Range (Forest Service 1982a). The rugged terrain, diverse rock forms, diverse vegetative patterns, or numerous water features that are found in the Walker Cove-Rudyerd Bay area are not present here. Slopes along these fjords are steep with moderate terrain diversity, uniformly forested with scattered rock outcroppings. The ridgelines are long and flat to rounded in form. Alpine areas along these ridges, with a few exceptions, do not exhibit any striking vegetative patterns, rock forms, or other features. Most of this area is designated variety class B (common). The entrance to Smeaton Bay is designated variety class C (minimal) because of low relief, uniform slopes and vegetative cover, and minimal landscape diversity.

Viewsheds (total land areas visible with an unobstructed line of sight) in the project area are frequently enclosed and restricted to foreground and middleground distance zones by prominent peaks that dominate the landscapes. Panoramic views are possible when viewing from a boat along Smeaton Bay and southern portions of Wilson Arm. These landscapes have been assigned variety class B (common), although both the Wilson Arm/Smeaton Bay and Boca de Quadra fjords contain some distinctive physical landscape features.

Wilson Arm/Smeaton Bay:

The mouth of Smeaton Bay is low relief with elevations ranging from 500 to 1,500 ft and uniform forest cover with little terrain or vegetation diversity. Progressing into the bay the slopes become steeper and the terrain more broken, elevations higher, and alpine ridges more prominent. Two major river drainages, the Wilson and Blossom rivers, discharge onto an extensive tideflat area at the head of Wilson Arm. The Tunnel Creek drainage, a prominent side drainage, extends east from the shoreline near the head of Wilson Arm. The steep forested side slopes of this symmetrical U-shaped valley frame the rock faces and vegetative patterns of the ridge at its head to create one of the more dramatic scenic features of the area. These features combine to add a complex spatial quality to the landscapes surrounding the Wilson Arm/Smeaton Bay fjord.

The other major scenic feature is Bakewell Arm, a smaller fjord extending eastward from Wilson Arm. Extremely steep forested slopes rising from sea level to nearly 3,500 ft border its northern shoreline, while the southern shoreline is more moderately sloped. Bakewell Creek drains nearby Bakewell Lake, oriented north-south across the wilderness/nonwilderness Monument boundary. Bakewell Lake's northern end lies in the nonwilderness area and represents the largest freshwater lake within the nonwilderness boundaries of the Monument.

Boca de Quadra:

The Boca de Quadra fjord is bordered by extremely steep forested slopes broken by pronounced drainages and V-notches. Diverse rock forms are prominent along slopes midway up the fjord. Approximately 10 mi south of the head of the fjord are extremely rugged and diverse rock forms and terrain features, rated variety class A (distinctive). The head of the fjord is more uniform and rock outcroppings less frequent.

The Keta River flows into the head of the fjord and its valley is in direct alignment with the general north-south orientation of Boca de Quadra. As a result, the degree of spatial diversity at the head of this inlet is less than in Wilson Arm. The tideflat at the head of Boca de Quadra is less extensive and diverse than in Wilson Arm. Boca de Quadra also has no side drainages as scenic as the Tunnel Creek valley of Wilson Arm. Thus, Boca de Quadra has less landscape diversity than the Wilson Arm area.

Scenic Resource Values

The scenic resource values of an area represent a hypothetical viewer's concern for the aesthetic qualities of a landscape. This concern or sensitivity level is derived from an assessment of the number and frequency of viewers, the duration of the viewing period, and the location of the viewing points. Three sensitivity levels are used to rate these factors, with Level I rating highest. These levels have been assigned to travel routes and use areas in the project area.

National Forest Service VRM guidelines (Forest Service 1974) dictate that wilderness areas have the highest sensitivity level (Level I). Therefore, the entire land area within the Misty Fiords National Monument wilderness and all adjacent water bodies are Level I. In the case of the nonwilderness area around Wilson Arm and Boca de Quadra, Level I areas are confined to the saltwater bodies and significant lakes, important air routes, and trails.

Smeaton Bay, Wilson Arm, Bakewell Arm, and Boca de Quadra are the prime saltwater use areas. These use areas extend a short distance up the Wilson, Blossom, and Keta rivers. The trail leading from Bakewell Arm to Bakewell Lake, as well as the lake's shoreline contained within the nonwilderness boundary, are also designated Level I. An additional significant travel route is the air route leading to the two Forest Service cabins on Wilson Lake. On days when the ceiling is too low to allow flights over the Punchbowl Lake and Big Goat Lake area the Wilson Arm and Wilson River valley is the alternative route to these cabins. A more detailed account of viewing related to recreational activities in this area is provided in Section 3.3.6, Recreation.

Visual Resource Management Objectives

The visual quality management objectives, as part of the VRM system, specify degrees of acceptable landscape alteration. The objectives are derived by evaluating the variety class (categories measuring the diversity and scenic quality of the natural landscape) and sensitivity levels (categories measuring viewpoints, number and frequency of viewers, and duration of viewing period). Five management objectives determine the level of management activity each landscape is able to accommodate and yet retain its natural aesthetic qualities:

1. Preservation (P) - No landscape management activities other than very low visual impact recreation facilities are permitted. This objective allows for ecological changes only.

2. Retention (R) - Landscape management activities must not be evident to the extent that they change the natural character of the landscape through introduction of unnatural forms, lines, colors, or textures. Alterations to the natural landscape features must not be evident.

3. Partial retention (PR) - Landscape management activities may repeat the form, line, color, or texture of the natural landscape but the landscape alterations must remain visually subordinate to the natural characteristics of the landscapes.

4. Modification (M) - Landscape management activities may visually dominate the natural landscape, but must repeat form, line, color, or texture that is characteristic of the natural landscape.

5. Maximum modification (MM) - Landscape management activities may visually dominate the natural landscape as seen within foreground or middleground viewing distances, but must visually blend with the natural features of the landscape when viewed in the background.

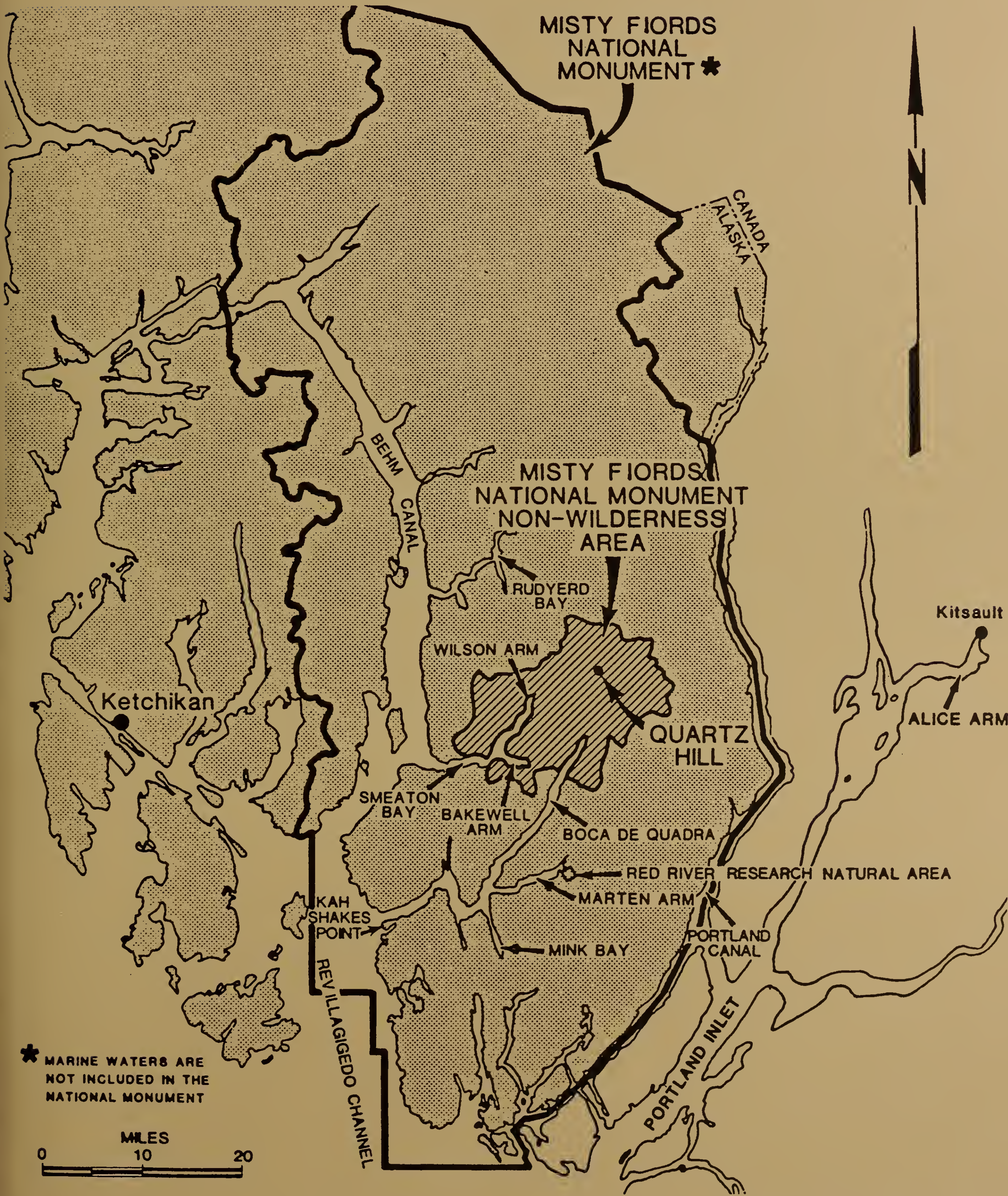
The scenic quality for the project area corresponds to the variety class B (common) rating assigned by the Forest Service. The use areas or travel routes from which viewing is most likely are assigned Level I (highest) viewing sensitivity values. The resulting visual quality management objective assigned to landscapes rated as such are retention for landscapes viewed within foreground distance zones, that is within 1/4 to 1/2 mi of the observer and partial retention for landscapes viewed within middleground distance zones. Middleground distance zones extend from the foreground zone to 3 to 5 mi from the observer. Monument landscapes surrounding the nonwilderness boundary are assigned preservation visual quality management objectives (Appendix M, Figure M-1).

3.3.8 Power Resources

The existing electrical energy generating system in southeast Alaska is characterized by several intermediate sized hydroelectric power plants serving scattered loads in and around Juneau, Petersburg, Wrangell, and Ketchikan. The nearest existing hydropower plant to the Quartz Hill Project is Swan Lake, located 36 mi to the northwest. It has a capacity of 22 MW, which will be fully utilized by Ketchikan. In British Columbia there are also hydroelectric power plants within 100 mi of the Quartz Hill project area.

There has been a continuing interest in developing a high voltage transmission grid in southeastern Alaska. The communities of Petersburg, Wrangell, and Ketchikan formed a committee to study the possibility of constructing a transmission intertie. The Alaska Power Authority and the City of Ketchikan hired a consultant to study the power needs of the area. At this time, the Alaska Power Authority believes the intertie is economically feasible. Integrating the individual generating systems could improve the reliability of the entire network and could also minimize thermal generation needs by fully utilizing the available hydroelectric power.

4.0
ENVIRONMENTAL CONSEQUENCES



4.0 ENVIRONMENTAL CONSEQUENCES

This chapter discusses the environmental impacts of the proposed project and its alternatives, and it forms the scientific and analytic basis for the comparison of alternatives. This section is intended to provide the reader with a comprehensive analysis of the environmental impacts associated with each alternative as a basis for the decision making process. The impacts of U.S. Borax's proposed project, as described in Section 2.0, are evaluated in this section under the subheadings "Tunnel Creek Mill with Wilson Arm Tailings Disposal."

Impacts were assessed by first listing potential impacts for each resource and project component or alternative. Second, the level of impact was determined for the specific situations of each expected impact. Four components of impact level were used: magnitude (major, moderate, minor), extent (large, medium, small), duration (long term, intermittent, medium term, short term), and likelihood (probable, possible, unlikely). A matrix was used to rate the significance of the impacts. The following are the impact ratings used in this document: very significant, moderately significant, and insignificant; it is recognized that some components have no impact on some resources. The impact rating matrix and further discussion of its use are given in Appendix N.

Each element of the environment is discussed below to an extent consistent with the significance of the anticipated impacts. Thus, in this section less significant impacts are discussed briefly, while the more significant ones are analyzed in detail.

4.1 CONSEQUENCES ON THE PHYSICAL ENVIRONMENT

4.1.1 Meteorology/Air Quality

4.1.1.1 No Action

If the mine were not developed, then air quality in the region would remain in its present pristine state.

4.1.1.2 Tunnel Creek Mill with Wilson Arm/Smeaton Bay Tailings Disposal and Commute Option

Applicable Air Quality Regulations

The Alaska Department of Environmental Conservation (ADEC) considers the Tunnel Creek processing plant/marine terminal and the mine site to be two separate facilities for air quality licensing purposes (ADEC 1985). As discussed in Appendix C, the Tunnel Creek facilities will be subject to Prevention of Significant Deterioration (PSD) review because the potential of the gas turbine power plant to emit nitrogen oxides exceeds 250 tons/yr. All pollutants emitted in significant quantities at the Tunnel Creek site are then subject to control by methods that conform to Best Available Control Technology (BACT). These pollutants include point and fugitive emissions of total suspended particulate

matter (TSP), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and hydrocarbons (HC), which are precursors for the formation of ozone. Ambient concentrations of SO_2 must be within PSD Class II increments, while all other pollutants must be within Alaska State Ambient Air Quality Standards (ASAAQS). Both the gas turbine and the petroleum storage vessels are subject to New Source Performance Standards (NSPS). Federal and Alaska air pollution control regulations are in essential agreement concerning allowable emissions and concentrations at the Tunnel Creek site.

Under federal regulations, the mine site would not be a major stationary source because no pollutant is emitted in excess of 250 tons/yr (excluding tailpipe emissions from mobile sources). Therefore, under federal regulations, the mine site would not be subject to PSD and all pollutants would need to meet only the applicable ASAAQS. There is some ambiguity in the ADEC regulations, which do not define major stationary source and which do not exclude secondary emissions and fugitive emissions when determining whether a stationary source is subject to PSD review. The ADEC is revising the regulations to be consistent with federal regulations and the mine site will not be subject to PSD increments for particulate matter. The ore crusher at the mine site is subject to NSPS.

The EPA recently set allowable ambient limits for PM-10 particulates (particles smaller than 10 microns). The new PM-10 limits apply only to ambient concentrations, and not to PSD increments. The new PM-10 ambient limits replace the previous federal TSP ambient limits. The State of Alaska must implement the new PM-10 ambient standard, and may choose to discontinue the previous TSP ambient limit.

Predicted Pollutant Emission Rates

The methods used to calculate the air pollutant emissions from the power plant, mill, and mine site are described in detail in Appendix C. The calculated highest 24-hour emission rates and the annual average emission rates for all regulated pollutants from the 80,000 tpd facility are summarized in Table 4-1.

Impacts at Tunnel Creek

The emissions from the Tunnel Creek power plant would have a moderate effect on air quality. However, EPA-approved computer modeling showed that no exceedances of air quality regulations are expected, even under worst-case conditions. As discussed in Appendix C, the power plant emissions were modeled using the COMPLEX I model, with wind data for 1984. The predicted worst-case impacts are compared to the allowable PSD increments in Table 4-2. In all cases, the predicted impacts are much less than the allowable PSD increments. In general, the power plant plume rises to a sufficient elevation to pass over the bluffs near the plant, then travels downvalley until it impacts the ridge across Wilson Arm.

TABLE 4-1
SUMMARY OF EMISSIONS
80,000 TPD FACILITY

Operations	Uncontrolled (lbs/hr)	Maximum 24-hr (lbs/hr)	Annual Average (tons/yr)
<u>Tunnel Creek Valley</u>			
Power Plant			
PM	N/A	3.6	13.7
SO_2	N/A	31	134
NO_x	N/A	217	955
CO	N/A	67	294
VOC	N/A	24	107
Coarse Ore Stockpile			
Load-in by Conveyor Transfer Point	0.16	0.05	0.21
Wind Erosion	0.1	0.01	0.02
Load-out from Coarse Ore Stockpile	N/A	0.01	0.03
Petroleum Storage Tanks			
Power Plant Fuel			
Breathing Losses	N/A	0.1	0.3
Working Losses	N/A	0.1	0.3
Diesel Fuel Storage			
Breathing Losses	N/A	Neg.	0.1
Working Losses	N/A	Neg.	0.1
<u>Concentrator Access Road</u>			
Fugitive Dust	N/A	0.7	0.3
Tailpipe Emissions			
CO	N/A	0.4	1.8
NO_x	N/A	0.1	0.3
PM	N/A	Neg.	0.1
VOC	N/A	0.1	0.2
<u>Mining Operation Sources</u>			
Drilling of Ore and Waste Rock	0.7	0.5	2.2

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TABLE 4-1 (Continued)
SUMMARY OF EMISSIONS
80,000 TPD FACILITY

Operations	Uncontrolled (lbs/hr)	Maximum 24-hr (lbs/hr)	Annual Average (tons/yr)
Mining Operations (Continued)			
Blasting of Ore and Waste Rock	8.5	8.5	37.2
Waste Rock Removal	0.1	0.1	0.1
Waste Rock Haulroad			
Fugitive Dust	905.6	135.8	112.6
Tailpipe Emissions			
NO_x	N/A	806.7	1,032.0
HC	N/A	12.6	16.1
CO	N/A	115.2	147.5
PM	N/A	26.4	33.8
Waste Rock Dumping	0.3	0.3	1.4
Waste Rock Stockpile Wind Erosion	0.9	0.9	1.4
Ore Removal	0.1	0.1	0.1
Ore Haulroad			
Fugitive Dust	737	110.6	91.7
Tailpipe Emissions			
NO_x	N/A	806.7	1,033.0
HC	N/A	12.6	16.0
CO	N/A	115.2	147.0
PM	N/A	26.4	34.0
Primary Crushing of Ore	N/A	0.7	2.9
Petroleum Storage			
Diesel Fuel			
Breathing Losses	N/A	Neg.	Neg.
Working Losses	N/A	Neg.	Neg.
Unleaded Fuel			
Breathing Losses	N/A	Neg.	Neg.
Working Losses	N/A	Neg.	0.3

TABLE 4-1 (Continued)
SUMMARY OF EMISSIONS
80,000 TPD FACILITY

Operations	Uncontrolled (lbs/hr)	Maximum 24-hr (lbs/hr)	Annual Average (tons/yr)
Residence/Dining Buildings			
PM	N/A	0.1	0.2
SO_2	N/A	0.2	0.9
CO	N/A	0.1	0.6
HC	N/A	Neg.	0.1
NO_x	N/A	0.6	2.8
Crusher/Mine Service Building			
PM	N/A	0.1	0.6
SO_2	N/A	0.5	2.2
CO	N/A	0.4	1.6
HC	N/A	0.1	0.3
NO_x	N/A	1.6	6.9
Mine Access Road			
Fugitive Dust	N/A	4.51	3.74
Tailpipe Emissions			
CO	N/A	0.66	2.88
NO_x	N/A	0.09	0.41
PM	N/A	0.02	0.07
VOC	N/A	0.07	0.29
Wilson Area Wharf			
Power Plant Fuel Storage			
Breathing Losses	N/A	Neg.	0.2
Working Losses	N/A	0.1	0.3
Diesel Fuel Storage			
Breathing Losses	N/A	Neg.	0.1
Working Losses	N/A	Neg.	0.1
Unleaded Fuel			
Breathing Losses	N/A	Neg.	Neg.
Working Losses	N/A	0.1	0.3
Planes and Helicopters			
SO_2	N/A	0.1	0.02
PM	N/A	-	-
CO	N/A	0.6	2.7
HC	N/A	0.1	0.3
NO_x	N/A	0.1	0.1

TABLE 4-1 (Continued)
SUMMARY OF EMISSIONS
80,000 TPD FACILITY

Operations	Uncontrolled (lbs/hr)	Maximum 24-hr (lbs/hr)	Annual Average (tons/yr)
Tugboats (20 trips/yr)			
SO_2	N/A	0.4	0.1
PM	N/A	0.8	0.2
CO	N/A	0.4	0.1
HC	N/A	0.4	0.1
NO_x	N/A	2.1	0.5
35,000 DWT Tanker (10 trips/yr)			
SO_2	N/A	68	1.2
PM	N/A	16	0.3
CO	N/A	0.5	0.1
HC	N/A	2.5	0.1
NO_x	N/A	42	0.6

TABLE 4-2
CALCULATED WORST CASE AIR QUALITY IMPACTS

Pollutant and Averaging Time	Maximum Impact (ug/m^3)	PSD Class II Increment (ug/m^3)	Alaska Ambient Standard (ug/m^3)
<u>TUNNEL CREEK</u>			
Power Plant Particulates (TSP)			
o Annual	5.2 1/	N/A 2/	60
o 24-Hour	7.5 1/	N/A	150
Power Plant SO_2			
o Annual	1.81	20	80
o 24-Hour	21.5	91	365
o 3-Hour	39.7	512	1,300
Power Plant NO_x			
o Annual	5.1	None Established	100
Fugitive Dust (TSP)			
o Annual	5.1 1/	N/A	60
o 24-Hour	10.0 1/	N/A	150
PM-10 Particulates			
o Annual	less than 5	None	50
o 24-Hour	less than 10	None	150
<u>MINE SITE</u>			
Fugitive Dust and Tailpipe TSP			
o Annual	6 1/	N/A 2/	60
o 24-Hour	146 1/	N/A	150
Nitrogen Oxides			
o Annual	47	None Established	100
PM-10 Particulates			
o Annual	less than 6	None	50
o 24-Hour	less than 146	None	150

1/ Includes 5 ug/m^3 background value for TSP.
2/ Not applicable. PSD increments for TSP do not apply at either Tunnel Creek or mine site. PSD increments for SO_2 do not apply at mine site.

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Impacts at the Mine Site

As discussed in Appendix C, the impacts of fugitive dust and tailpipe emissions at the mine site were calculated using the ISC computer models. Year 16 of the mining operations was used as the base case for predicting the pollutant rates shown in Table 4-1. On-site meteorological data for the period 1981-82 were used for the modeling.

The air quality impacts of the mining operations would be significant. However, EPA-approved computer modeling showed that no exceedances of air quality regulations are expected, even under worst-case conditions. The calculated highest 24-hour and annual average impacts at the mine site are shown in Table 4-2. The isopleths of the calculated highest 24-hour TSP impacts for the period 1981-92 are shown in Figure 4-1. For dry days with low wind speeds, the calculated 24-hour average TSP concentration at the project boundary is slightly less than the allowable 150 ug/m^3 ASAAQS standard. As discussed in Appendix C, there are an average of 69 dry days per year during the summer and autumn seasons at Quartz Hill. Because of the wet weather during most of the year, the calculated annual-average fugitive dust impacts are minimal.

Table 4-2 also shows that the impacts of Tunnel Creek and mine site operation on ambient fine particle concentrations will be less than the newly established federal PM-10 limits.

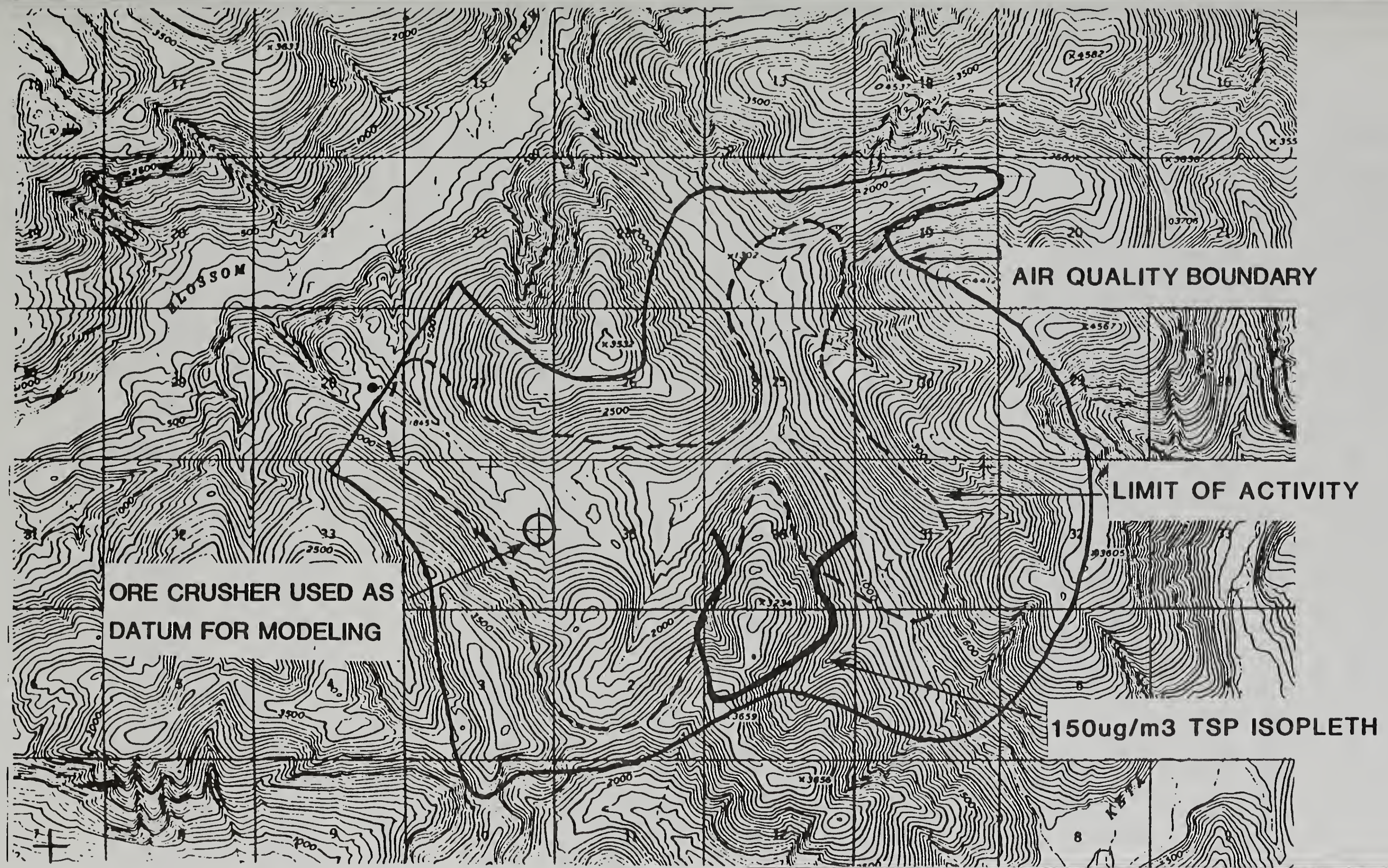
As described in Section 5.5 of Appendix C, the calculated visibility impacts at Tunnel Creek and the mine site were insignificant.

4.1.1.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

For this alternative, the air quality impacts at Tunnel Creek and the mine site would be similar to those discussed in Section 4.1.1.2. However, there could be significant air quality impacts caused by wood stove emissions from the permanent townsite, especially during periods of strong inversions. It is possible that the Alaska Department of Environmental Conservation could impose a ban on wood stoves as a condition in their air quality permits for the Quartz Hill project (Chapple 1984).

4.1.1.4 Beaver Creek Mill Alternatives

The emissions from the Beaver Creek power plant stack would probably cause insignificant air quality impacts. Although no detailed modeling of the Beaver Creek emissions was conducted, the plume trajectory and downwind concentrations should be similar to those modeled for the Tunnel Creek plant (Section 4.1.1.2). The worst case impacts would therefore be much less than the allowable air quality limits.



N

1 MILE

NOTE: INCLUDES ASSUMED
5ug/m3 BACKGROUND
TSP CONCENTRATION

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

CALCULATED WORST CASE
24 HOUR TSP IMPACTS AT MINE
SITE FOR DATA PERIOD 1981-82

SOURCE DATE

FIGURE
4-1

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

The fugitive dust emissions from the mine site would be unaffected by the location of the mill and power plant. The fugitive dust impacts near the mine site would therefore be the same as those described in Section 4.1.1.2.

4.1.1.5 North Meadow Mill Alternatives

Emissions from the North Meadow power plant stack would cause insignificant air quality impacts. As discussed in Appendix C, the North Meadow impacts were estimated using the EPA-approved Valley/F/2.5 screening analysis (EPA 1977). The calculated worst case SO_2 impact was only 4.4 ug/m^3, which is much less than the allowable 24-hour PSD Class II increment of 91 ug/m^3. Based on this screening analysis and detailed modeling of the Tunnel Creek site, the impacts of the regulated pollutants would be insignificant at this site.

4.1.1.6 On-Land Tailings Disposal Dams

Some of the project alternatives specify mine tailings disposal behind earthfill dams. Construction of those earthfill dams would probably cause significant air quality impacts during the summer months with low wind speeds and poor atmospheric dispersion. As discussed in Appendix C, the fugitive dust emissions from dam construction on dry days could be as high as 200 lbs/hr. Those high fugitive dust emissions may cause exceedances of particulate ambient air quality standards (TSP and PM-10) downwind of the dams, depending on where the regulatory agencies established the "air quality boundary" around the dam sites.

4.1.2 Geology and Soils

4.1.2.1 No Action

Impacts on geologic and soil resources would be confined to minor topographic alterations and soil erosion associated with bulk sampling and access road maintenance. These are discussed in the Road Access and Bulk Sampling EIS (Forest Service 1982a, pp. 4-12, 13). Temporary impacts due to any reclamation activities would also be insignificant.

4.1.2.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

During the construction phase of the project, no geologic resource would be significantly affected. Soil impacts would result from the removal and stockpiling of mine pit overburden and from construction of roads and mine support facilities. The major soil impact would be caused by the stockpiling of 13 million cubic feet (mcf) of muskeg and 20 mcf of glacial till. Long-term stockpiling would result in lower soil fertility, reduced cation exchange capacity, and reduced biological activity (U.S. Borax 1983a, pp. 8-15).

The primary construction phase soil erosion impacts would be from road-induced landslides along the Blossom River access road due to widening of the access road. Additional erosion would occur from construction of the two water quality control facilities and mine service facilities in the Beaver Creek basin, the processing facilities and water supply reservoir in the Tunnel Creek basin, and at the adits of the ore transport and tailings disposal tunnels. Net soil impacts would be moderately significant.

During the mining phase, the project would use a nonrenewable geologic resource by removing the molybdenum ore body from Quartz Hill. No unique resources such as fossil fuels or unusual geologic formations are known to exist within the affected area. Other than the use of the ore body, there would be no significant impact to the geologic environment from the operation of the project.

The most significant topographic alterations would result from development of the mine pit and waste rock disposal areas. Quartz Hill would be lowered in elevation 1,875 ft by pit excavation and Beaver and Hill creek valley elevations would be raised as much as 900 ft by the waste rock piles.

Soil disturbance and erosion associated with facility operation would occur at the Tunnel Creek plant site, the Blossom access road, and the mine service area. The effects of erosion from the access roads on water quality are discussed in Section 4.1.5. The mining period would involve the removal of an additional 25 mcf of muskeg and 76 mcf of glacial till. Ultimate development of the mine pit would result in long-term permanent disturbance of about 1,040 ac. Development of waste rock disposal, mine service, and related facility areas would cover 1,550 ac, and would result in permanent disturbance. Soil impacts would therefore be moderately significant.

4.1.2.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

The Bakewell townsite would require excavation or compaction of approximately 60 ac of muskeg. Backfilling would be necessary and would entail filling with excavated material taken from the knob-like area within the townsite. The Wilson I townsite would occupy 120 ac and entail extensive cut and fill operations. Wilson IIa would also require cut and fill operations. Development of any townsite would therefore result in moderately significant topographic impacts in addition to those described in Section 4.1.2.2.

Development of the Bakewell, Wilson I, or Wilson IIa townsite would require the disturbance of 200, 120, or 200 ac of soil, respectively. Erosion impacts associated with access roads to townsites are discussed in Section 4.1.5. All other geologic and soil impacts would be similar to those described in Section 4.1.2.2.

4.1.2.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

Topographic impacts for this alternative would not be significantly different from those discussed in Section 4.1.2.2 for both the construction and mining periods. During construction, minor soil impacts would result from widening the right-of-way along the access road to accommodate the tailings pipeline as discussed in Section 4.1.5. Mining period soil impacts would be similar to those described in Section 4.1.2.2.

4.1.2.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

Geologic impacts would not be significantly different from those of the project described in Section 4.1.2.2. Additional minor soils impacts would result from the construction of a substantially longer tailings disposal line and the Raspberry Creek water supply reservoir. Soil impacts during the mining and postmining periods would essentially be the same as described previously.

4.1.2.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

There are no significant differences between this alternative and the Beaver Creek with Boca de Quadra tailings disposal alternative (Section 4.1.2.5).

4.1.2.7 Beaver Creek Mill with On-Land Tailings Disposal

The construction of additional roads for access to the pipeline and tailings dams would create additional minor topographic and soils impacts. During the mining period, staged construction of tailings dams would cause progressively greater impacts on topography and soils. Final design heights and lengths of the dams are approximately 1,000 ft high and 1 mi long for the Tunnel Creek site and approximately 780 ft high and 2/3 mi long for the Aronitz Creek site. Tailings disposal would cover 2,700 ac in the two valleys. Impacts to soils would be moderately significant. Reclamation of tailings disposal areas would consist of stabilization and revegetation and would create long-term topographic impacts.

4.1.2.8 North Meadow Mill with Boca de Quadra Tailings Disposal

This alternative would require the construction of an additional 3 mi of access roads and an additional 5 mi of tailings disposal line. Topographic and soils impacts would not be significantly different than those described in Section 4.1.2.2. This alternative would also entail a townsite adjacent to the Keta River, which would modify the topography. Impacts during the mining and postmining periods would be essentially identical to those discussed in Section 4.1.2.2.

4.1.2.9 North Meadow Mill with On-Land Tailings Disposal

Impacts associated with this alternative would be similar to those discussed for Section 4.1.2.7.

4.1.3 Surface Water Hydrology

4.1.3.1 No Action

No changes in existing surface water flow regimes would occur with the no action alternative.

4.1.3.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

Construction Period

Preproduction construction activities would be concentrated in the Beaver and Tunnel creek basins. The disturbed areas in Beaver Creek, representing about 15 percent of the drainage basin, would have slightly higher storm runoff than under existing conditions, resulting in a small increase in average annual flow. Because runoff volumes are a high percentage of total precipitation under natural conditions, this is not expected to be a significant impact. Water withdrawals from Beaver Creek during the construction period have not been defined, but they are not expected to significantly affect Beaver Creek flows.

All runoff from disturbed areas in the Beaver Creek basin would be routed through at least one of two interim water quality control facilities during the construction period. Water levels in the ponds would be maintained so that pond outflow would be approximately equal to inflow. The ponds will therefore not affect average annual flow or low flows but will dampen peak flows somewhat.

Blossom River streamflows downstream of Beaver Creek are not expected to be significantly affected by changes to Beaver Creek's flow regime during the construction period. The area upstream of the lower pond on Beaver Creek represents only 3 percent of the total Blossom River drainage area.

The White Creek drainage basin would not be affected during the construction phase, thereby avoiding impacts to White and Hill creeks and the Keta River.

Runoff from disturbed areas in the Tunnel Creek basin, including the mill area, camp, and tunnel adit, would be routed through a water quality control facility. Because the disturbed area (210 ac) represents only 3 percent of the total Tunnel Creek drainage area, Tunnel Creek streamflow is not expected to be significantly affected. No other hydrologic regimes in the project area would be significantly affected during the construction phase. Dredge and fill activities associated with road construction and other facility development would not significantly affect normal water level fluctuations in the project area.

Mining Period

During the mining phase of the project, mining and ore processing activities and associated facilities would primarily affect Beaver, White, Hill, and Tunnel creeks; the Wilson (downstream of the confluence with the Blossom River), Blossom, and Keta rivers would also be affected to a lesser extent.

Flow regimes in the Beaver Creek basin would be impacted by drainage area changes due to pit development, extensive surface disturbance, water supply withdrawals, and routing of runoff through water quality control facilities. Mining facilities in the basin would include the mine pit, mine service facilities, crusher, access road, and camp. Muskeg, glacial till, snow, and waste rock would be stockpiled in the basin. Water supplies for the crusher, mine service facilities, and camp would be withdrawn from tributaries of Beaver Creek at an average rate of 69 gpm. Runoff from all disturbed areas would be routed through the Beaver Creek interim water quality control facility for the first several years of the mine life, and later through the Beaver Creek permanent water quality control facility.

Ultimately, approximately 60 percent of the Beaver Creek basin would be disturbed. The mine service area, camp site, and access roads would exhibit a higher runoff response than natural areas due to lack of vegetation and compaction of the upper layers from mining equipment and other vehicles. The ground surface below the waste rock pile would become compacted from the weight of the waste rock and from grading and dumping activities over the surface of the pile, resulting in less infiltration than under natural conditions. Snow disposal areas in the basin may slightly increase spring snowmelt runoff in Beaver Creek.

For the first 6 years of operation, drainage from the mine pit, including intercepted groundwater and precipitation, would flow by gravity into drainage ditches at the toe of the mine and then be routed into the Beaver Creek water quality control facility. This includes a maximum of approximately 361 ac that now drain to White Creek. Beginning at year 6, the pit would be deep enough to require pumping as the primary means of pit dewatering. Drainage water pumped from the pit would be routed to the Hill Creek water quality control facilities. Approximately 410 ac that now drain to Beaver Creek would become part of the pit; with the pumping of pit waters to Hill Creek, the Beaver Creek drainage area would be reduced by this amount.

Beaver Creek annual flows would be at their minimum levels at year 55 and are estimated to be about 28 percent lower than natural conditions below the water quality control facility and 22 percent lower at the mouth (Appendix D). Impacts to average annual flow in Beaver Creek would be moderately significant.

Low flows in Beaver Creek during the mining phase would be affected by disturbance of surficial deposits and wastewater treatment plant discharges. The natural 7-day, 10-year low flow of 0.5 cfs at the water quality control facility would be increased to 0.6 cfs at year 55. The corresponding flow near the mouth of Beaver Creek would be changed from 0.6 to 0.7 cfs (Appendix D). Low flows would therefore not be significantly affected. Peak flows would be dampened considerably by the water quality control facilities, resulting in moderate peak flow impacts.

The Blossom River flow regime would not be significantly affected by project facilities in the Beaver Creek basin, because of the relatively small area above the water quality control facility. Average annual and low flows would change by less than 1 percent (Appendix D).

Supplemental water supplies withdrawn from the Blossom River just upstream of its confluence with the Wilson River could reduce the discharge by up to a maximum of 36 cfs. This is expected to result in no significant impacts because most (see Table 3-11) salmon spawning occurs upstream of this location. Also, streamflows downstream of the facility are expected to be sufficient to allow for successful passage of fish (see Section 3.2.1). Potential problems with entrainment or impingement of fish in the intake system will be avoided through use of the filtration collector system located in the stream bed. Any potential impacts would also be negated by flows in the Wilson River and tidal influence, which slows the flow of the Blossom River in the intake area on a cyclical basis ($\pm$6 hr cycles). Additionally, potential impacts associated with the Blossom River intake structure would be controlled through requirements of the ADF&G's fish habitat permit.

Flow regimes in the White and Hill creek basins would be affected by the mine pit, the waste rock pile, snow disposal areas, and the White Creek and Hill Creek water quality control facilities. No water withdrawals are planned for this basin. White Creek would essentially no longer exist during or after project operation because the headwaters would be excavated for the pit and the stream valley would be filled with waste rock. White Creek hydrology would therefore be very significantly affected.

During year 6 of operation, when pit drainage is still routed to Beaver Creek, average annual flows in Hill Creek would be 4 percent lower than natural conditions at the water quality control facility and 3 percent lower at the mouth (Appendix D). At the end of the mine's life, when pit drainage is routed to Hill Creek, average annual flows would be about 8 percent higher than natural conditions at the pond, and 7 percent higher at the mouth, primarily due to the added drainage area from the pit (Appendix D).

Low flows in Hill Creek would also be at their minimum level at year 15, and their maximum level at year 55. The 7-day, 10-year low flow at year 15 would be reduced from 4.8 to 4.0 cfs at the pond (17 percent reduction) and from 5.8 to 5.0 cfs at the mouth (14 percent reduction). The corresponding low flow at year 55 would be increased 40 and 33 percent at the Hill Creek sedimentation pond and mouth, respectively. Low flows would therefore be moderately significantly affected.

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The area above the Hill Creek water quality control facility represents 16 percent of the Keta River drainage area. Changes in Hill Creek flows would affect Keta River average annual and low flows at the mouth by less than 2 percent, an insignificant amount (Appendix D).

The Tunnel Creek basin would be affected by the processing plant, power plant, camp, and water quality control facility. The power plant and processing plant near Tunnel Creek would require 16,000 gpm (36 cfs) to be withdrawn from Tunnel Creek, or 60 percent of the average annual flow at the reservoir. This demand exceeds the average monthly flow for 3 months of the year, and represents more than 50 percent of the average monthly flow at the reservoir for 8 months (Appendix D). Average annual flow at the mouth of Tunnel Creek would be reduced by 29 percent. Instream flow requirements will minimize impacts to fish habitat downstream of the reservoir. The 7-day, 10-year low flow would be dependent on these instream flow levels. Minimum instream flow regulations have not been established for Tunnel Creek. However, the NMFS and USFWS are recommending instream flows equal to the lower of the following:

1) the natural flow, or
2) 90 cfs, July 1 - November 30
   15 cfs, December 1 - March 31
   30 cfs, April 1 - June 30

Based on these recommendations, a recent water supply evaluation report (Envirosphere 1987) concluded that project water supply requirements could be met with a 52-ft-high dam on Tunnel Creek, which creates a reservoir that would be used as a primary water supply. This would be supplemented by withdrawals from the Blossom River. Monthly flow patterns, low flows, and peak flows would all be moderately significantly impacted.

Although no longer included in the proposed project, water withdrawals from the Wilson River could be used to supplement Tunnel Creek water as needed. The entire 16,000 gpm (36 cfs) needed in the processing plant represents less than 3 percent of the average annual flow; therefore, supplemental withdrawals would not significantly affect average annual Wilson River streamflows. The 7-day, 10-year low flow would be reduced from 104.1 to 68.5 cfs at the well site (34 percent reduction) and from 196.7 to 161.1 cfs at the Wilson River mouth (18 percent reduction) if the entire 36 cfs were withdrawn from the Wilson River during the low flow period. Low flows would therefore be moderately significantly affected.

No other streamflow regime would be significantly affected by this alternative project concept. No other water uses or water rights other than those associated with the project would be affected.

Reclamation Period

After project operations have ceased and rehabilitation is complete, all disturbed areas would have runoff coefficients similar to natural conditions. All water quality control facilities would be sufficiently

altered to ensure stability or be removed, and the pit would be allowed to fill with water, acting as a lake. Overflow from the pit would drain into Hill Creek.

The Beaver Creek drainage area would be smaller than the existing natural basin, resulting in flows about 25 percent lower than natural conditions at the mouth (Appendix D). Until it fills with sediment or is removed, the water quality control pond would regulate low and peak flows, and would dampen daily fluctuations in streamflow. The changed topography of the basin would not significantly affect the hydrologic regime. Net hydrologic impacts would be moderately significant in Beaver Creek. Blossom River flows would not be significantly affected (less than 1 percent change).

Much of the original White Creek and Hill Creek basins would be filled with waste rock. During approximately the first 14 years after the completion of mining, the pit would be filling with water and would not discharge. During this period, the average annual flow in Hill Creek at the mouth would be reduced by about 7 percent. After the pit fills with water, the Hill Creek basin would be larger than its existing size and would have a lake in the abandoned pit. Average annual flows would not be significantly affected (an increase of 4 percent at the mouth; see Appendix D). Keta River average annual flow would change less than 1 percent from natural conditions, an insignificant change. If the water quality control pond is removed, low flow conditions of both basins would not differ significantly from existing conditions.

Tunnel Creek average annual flow would return to natural levels when water withdrawals cease. No other drainage basin would have streamflows significantly different from natural conditions after reclamation is complete.

4.1.3.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

The Upper Hill Creek diversion option would result in a 17 and 14 percent reduction in average annual flow at the Hill Creek water quality control facility and mouth, respectively, at year 55 (Appendix D). The Hill Creek 7-day, 10-year low flow at year 55 would be higher than existing conditions because the water lost from the diversion (0.8 cfs) is less than the groundwater intercepted by the pit and routed to Hill Creek (2.7 cfs). Before the pit fills with water, the 7-day, 10-year low flow in Hill Creek below the water quality control facility would be 33 percent below the existing low flow. After the pit has filled, the 7-day, 10-year low flow would approximate existing low flows.

North Creek average annual flows would increase from 20 to 54 cfs, or a 170 percent increase. The 7-day, 10-year low flow would be increased from 0.4 to 1.2 cfs or a 200 percent increase.

Water withdrawals for domestic purposes at any of the potential townsite locations would average only 0.5 cfs, a small fraction of any potential source stream. Because the townsite acreage represents only a small portion of a basin, increased runoff in the urban areas would not significantly affect flow volumes. The townsite alternatives would therefore not significantly affect the streamflow regimes of any project area streams, regardless of townsite location. All other hydrologic impacts would be identical to those described in Section 4.1.3.2.

A temporary shutdown of the mine would not significantly affect streamflows in the project area. Most project operations that affect streamflow would continue during the shutdown, including pit dewatering, water supply withdrawals, and wastewater treatment plant discharge.

4.1.3.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The location of the tailings disposal line does not affect the hydrologic regime of any streams in the area; therefore, the impacts of this alternative would be identical to those described in Section 4.1.3.2.

4.1.3.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

Location of the mill in Beaver Creek would affect the disturbed acreage in the Beaver Creek basin by less than 10 percent and would not significantly affect the water supply obtained from the creek. The impacts to the Beaver Creek basin would, therefore, be similar to those described in Section 4.1.3.2.

Obtaining water supplies from Raspberry Creek would severely impact the hydrologic regime of the stream. Approximately 16,000 gpm (36 cfs) are needed for the mill, which is more than double the average annual flow at the possible reservoir site. Average monthly flows at the reservoir are less than process demands for all months of the year. If all available water were withdrawn from the reservoir, average annual and low flows would be reduced 40 percent and 33 percent, respectively from natural conditions at the mouth of Raspberry Creek (Appendix D). Average annual flow, monthly streamflow patterns, low flows, and peak flows would all be very significantly impacted by the water supply reservoir. If the power plant is located at the Beaver Creek mill, Tunnel Creek hydrology would be unmodified.

However, if the power plant is located in the Tunnel Creek basin, water withdrawals would average 14,500 gpm (32.4 cfs) from Tunnel Creek, or approximately 54 percent of the average annual flow at the water supply reservoir. All elements of the Tunnel Creek hydrologic regime would be moderately significantly impacted.

All other stream impacts would be the same as those described in Section 4.1.3.2.

4.1.3.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

Hydrologic impacts from this alternative would be identical to those defined in Section 4.1.3.5.

4.1.3.7 Beaver Creek Mill with On-Land Tailings Disposal

For this alternative, tailings would be disposed into tailings impoundments in the Tunnel and Aronitz creek basins. The hydrologic impacts of all other streams would be the same as those described in Section 4.1.3.2.

Because nearly the entire length of Tunnel Creek and Aronitz Creek would be buried, the hydrologic regimes of these streams would be essentially destroyed. The Tunnel Creek tailings pond spillway terminus is located less than 50 ft from the mouth of Tunnel Creek. Flood flows would therefore affect only 50 ft of the Tunnel Creek stream bed. Releases from the Aronitz Creek tailings pond, including flood flows, would be routed directly into Boca de Quadra, thereby essentially dewatering the remaining 1 mi of stream bed downstream of the dam. Hydrologic impacts would therefore be very significant for both creeks.

In the event of a catastrophic tailings dam failure, a very large flood and tailings sediment wave would quickly travel from the dam to the stream mouth. Hydrologic impacts would be very significant for these short reaches of the streams. Partial failure that releases a major part of the impounded water, even without major release of tailings, would also be very significant to the hydrology downstream.

4.1.3.8 North Meadow Mill with Boca de Quadra Tailings Disposal

The processing mill in North Meadow would disturb about 210 ac in the Hill Creek basin. Average annual flows, monthly streamflow patterns, low flows, and peak flows would be similar to those for the proposed project.

Water supply for the processing mill and power plant (36 cfs) would be obtained from an upper Hill Creek reservoir and from the Hill Creek water quality control pond. Average annual flow would be reduced 26 and 22 percent at the Hill Creek water quality control pond and mouth, respectively. Minimum streamflows would be maintained at a level approximately equal to those described in Section 4.1.3.2. Keta River average annual flows would not be significantly different than existing conditions.

No additional impacts would occur in Tunnel Creek, Wilson River (downstream of the confluence with the Blossom), or Blossom River with this alternative.

4.1.3.9 North Meadow Mill with On-Land Tailings Disposal

Impacts on Beaver Creek, Hill Creek, Blossom River, Wilson River (downstream of the confluence with the Blossom), and Keta River would be the same as those discussed in the previous section. Impacts on Tunnel and Aronitz creeks would be the same as those discussed in Section 4.1.3.7.

4.1.4 Groundwater Hydrology

For all of the alternatives discussed below, water levels in the project area would decline locally and some groundwater reserves would be lost. The impacts associated with these effects are, however, considered relatively insignificant from a regional perspective, due to their localized nature. More localized impacts are discussed below.

4.1.4.1 No Action

The adits would remain open and groundwater would continue to drain into them at the approximate rates of 45 gpm for the Bear Meadow adit and about 32 gpm for the Quartz Hill adit. The water levels in the bedrock surrounding the adits would remain depressed at about current levels, with up to almost 200 ft of water level decline in the Quartz Hill adit area, and up to 100 ft of decline in the vicinity of the Bear Meadow adit (Golder Associates 1983a, Fig. 5; Rowe 1983a, Fig. 3). This consequence would be both long term and probable, and thus locally classified as moderately significant.

4.1.4.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

During the construction phase, approximately 13 mcf of muskeg and 20 mcf of glacial till would be removed from the area of the mine pit. This would result in the destruction of the groundwater aquifers associated with those overburden deposits in the mine pit area. The groundwater storage capacity of the till and muskeg has not been specifically determined. However, the porosity of the glacial deposits has been estimated to be in the range 0.2 to 0.4 (Golder Associates 1983a, p. 7; Rowe 1983a, p. 3). Porosity of a medium can be taken as an upper bound of the storage coefficient. Assuming a maximum storage coefficient of 0.4 for both till and muskeg, the removal of 33 mcf of these materials would result in a loss of up to 100 million gallons of stored groundwater (compared with an estimated 50 billion gallons of water, which might be stored in all the muskeg, glacial, and alluvial deposits within the mapped area of Figure 3-2). Although this is a relatively small amount of water (equivalent e.g., to only 300 ac ft), the loss of this water would be both long term and probable, and thus locally classified as moderately significant.

Removal of minimal amounts of overburden would be required during the construction period in areas other than the pit area (e.g., at tunnel portals, in the mill area, and in the area of mine support

facilities). The consequences to the groundwater environment of removal of such materials would be rather minor, but both long term and probable, and thus moderately significant.

During the construction period, as the mine pit is prepared for major excavation, some groundwater inflow to the pit area from the bedrock formations would take place. This inflow is expected to be relatively small compared to the pit inflows during mining, and to be of short duration (i.e., limited to the preconstruction period).

Tunnels would be required for transport of ore to the Tunnel Creek mill site and transport of tailings to Boca de Quadra. Groundwater inflows to the tunnels during construction are assumed to be comparable to inflows experienced during construction of the Quartz Hill and Bear Meadow bulk sampling adits (maximum discharges of 165 gpm and 200 gpm, respectively). However, discharges should decline with time and approach steady state by the time the tunnels are placed into operation. Groundwater would also continue to discharge to the adits. The magnitude of such inflows is judged to be moderate to minor as inflow rates decline, so the impacts would be classified as moderately significant to insignificant.

During the operational phase of the project, overburden would continue to be removed from the pit area during the first few years of operation. It is estimated that 25 mcf of muskeg would be removed during the first five years of mining, and 76 mcf of glacial till would be removed during the first six years of mining. Assuming a maximum storage coefficient of 0.4 for both till and muskeg, the groundwater removed from storage by removal of these materials could be as much as 300 million gallons, compared with an estimated total of 50 billion gallons of water stored in these deposits throughout the entire project area. This would ultimately constitute total and permanent loss of the overburden aquifers in the pit area. This loss is considered a moderately significant impact at the scale of the project area as a whole.

Groundwater inflows to the pit would increase to an approximate steady state value between 700 and 2,000 gpm, with a most likely steady state value of about 1,200 gpm (Rowe 1983a, p. 29, Fig. 9). An estimate of the water level drawdown induced by mining has been made by applying Forchheimer's Equation (Bear 1972, pp. 379-380). The pit was idealized as having vertical walls spaced approximately 1 mi apart, having an average depth of 1,600 ft, and with an average distance of 1,700 ft between the pit boundary and adjacent ridge lines (see Figures II-1 and II-3 through II-5, Appendix A, for the actual pit geometry). Applying hydraulic conductivity and recharge values discussed in Section 3.1.4, this theory suggests that at the end of mining, groundwater levels may have declined by as much as 1,600 ft near the pit walls, and by as much as 850 ft beneath the ridges surrounding the pit area.

Groundwater inflows to ore transport and tailings disposal tunnels have been assessed by comparison with observed steady state groundwater inflows to the Bear Meadow and Quartz Hill bulk sampling adits. For both adits the stabilized discharge was about 0.02 gpm per linear ft. At this rate, the groundwater discharge to the ore transport tunnel could be 400 gpm, and the discharge to the tailings disposal tunnel could be 580 gpm, for a total groundwater discharge to project tunnels of about 980 gpm. Observed groundwater level reductions in the Bear Meadow and Quartz Hill areas approach 200 ft in the Bear Meadow area and almost 100 ft in the Quartz Hill area, but with declines greater than 10 ft confined to within 2,000 ft of the adits (Golder Associates 1983a, Fig. 5; Rowe 1983a, Fig. 3). Similar effects would be expected along the tunnels, with water level declines of up to 200 ft in the immediate vicinity of the tunnel, decreasing to less than 10 ft within a distance of 2,000 ft on either side of the tunnel.

After cessation of mining, several facilities would be dismantled or would no longer be used, and impacts associated with them would cease. At these areas, preexisting groundwater levels and flow regimes would gradually be reestablished.

The mine pit would be allowed to flood and be retained as a reservoir. Groundwater inflows to the pit would decline as water levels in the pit rise. Eventually, an equilibrium would be established between inflows to the pit (surface water runoff and groundwater inflows) and outflows to local surface water drainages.

Ore transport and tailings disposal tunnels would be reclaimed to prevent any discharges of contaminated water. Groundwater discharges from the sealed tunnels would gradually return to natural groundwater quality.

Assuming that the Tunnel Creek reservoir is removed following termination of mining, seepage would cease and groundwater conditions would revert to their preproject state. Percolation through waste rock piles would probably persist through this period, and associated changes in groundwater levels would be essentially permanent.

4.1.4.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

Consequences of this alternative would be essentially the same as discussed in Section 4.1.4.2. Muskeg stabilization by surcharging and compacting at a Bakewell townsite should have a negligible effect on the local alluvial aquifer. Filling of the floodplain at the Wilson IIa townsite could result in negligible water level increases in that vicinity. The route of an optional highway tunnel from the Bakewell townsite to the Tunnel Creek plant site has not yet been defined. However, the consequences of groundwater inflows to such a tunnel would be similar to those previously discussed for the ore transport and tailings disposal tunnels. The alternative tailings disposal tunnel (Figure III-1, Appendix A) could increase groundwater inflows from 980 to 1,280 gpm.

4.1.4.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

Consequences of this alternative would be essentially the same as described in Section 4.1.4.2. The consequences of construction of a townsite would be essentially the same as described in Section 4.1.4.3.

4.1.4.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

Consequences of this alternative would be essentially the same as discussed in Section 4.1.4.2, with consequences of townsite options as described in Section 4.1.4.3.

4.1.4.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

For most impacts, the consequences of this alternative would be essentially the same as for the project described in Section 4.1.4.2, with consequences of townsite options as described in Section 4.1.4.3. However, since this alternative involves neither an ore transport nor a tailings disposal tunnel, there would be no consequences associated with groundwater inflows to tunnels.

4.1.4.7 Beaver Creek Mill with On-Land Tailings Disposal

In general, the consequences of this alternative would be essentially the same as those described in Section 4.1.4.6, except for those associated with on-land tailings disposal, which are discussed below.

Tailings would be disposed of behind two impoundments. Because of the relatively high water content of the tailings and the high precipitation in the area, leachate is likely to be generated, which would percolate into underlying alluvial aquifers. Groundwater levels in the alluvium are likely to increase, creating gradients, which may result in percolation of leachate into the underlying bedrock. Since the tailings dams will be founded on rock (U.S. Borax/Bechtel 1983, Appendix B), leachate within the alluvium will generally not be able to migrate downgradient, but would have to percolate downward into bedrock. Existing data are insufficient to permit quantifying these effects.

In general, the stream valleys in the Quartz Hill area serve as discharge areas for the bedrock aquifers. Consequently, leachate within the bedrock would be expected to migrate in a downstream direction, toward areas of lower land surface elevation, and ultimately discharge to Tunnel Creek or Aronitz Creek at some point downgradient. Because the Tunnel Creek dam is so close to the mouth of the creek, leachate transported through the bedrock aquifer might actually discharge to Wilson Arm rather than the creek. A similar effect is possible, although less likely, at the mouth of Aronitz Creek.

Potential groundwater impacts of this alternative are primarily groundwater quality degradation, as discussed in Section 4.1.5.7. Secondarily, the presence of the impoundments within natural discharge areas of the bedrock aquifers will reduce the amount of potential

groundwater baseflow to the creeks as a result of discharge from the bedrock aquifers. This latter effect, however, is less significant than the more direct impacts on the streams as a result of the presence of the impoundments.

Following termination of mining, tailings impoundments would remain in place, but would be drained. Leachate would continue to be generated, although at a lower rate because the impoundments would be allowed to drain, and groundwater levels in underlying aquifers would remain elevated. Since, under natural conditions, groundwater levels in the area are expected to closely follow the topography, these effects are expected to be permanent.

4.1.4.8 North Meadow Mill with Boca de Quadra Tailings Disposal

The consequences of this alternative should be essentially the same as those described in Section 4.1.4.6, except that there would be no Blossom River supplemental water supply facility, and thus no consequences associated with that facility.

4.1.4.9 North Meadow Mill with On-Land Tailings Disposal

The consequences of this alternative should be essentially the same as those described in Section 4.1.4.7, except that there would be no Blossom River supplemental water supply facility, and thus no consequences associated with that facility.

4.1.5 Water Quality

4.1.5.1 No Action

The impacts of maintaining the existing activities were discussed in the road access and bulk sampling EIS (Forest Service 1982a).

The presently existing effects on water quality of sediment runoff from the access road and other disturbed surfaces, and the discharges from the adits, water quality contol facilities, and other existing facilities would continue. According to the 1983 Benchmark Water Resources Report (VTN 1983a), only minor variations in water quality were detected during 1983, compared to existing data. Most of the increases in constituent levels were attributed to natural variation in water quality. An exception was Beaver Creek, which exhibited a high suspended sediment level due to instream activities associated with access road construction.

4.1.5.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

Construction Phase

Preproduction activities that would affect water quality are concentrated mainly in Tunnel Creek, Beaver Creek, and other watersheds of the Blossom River. These activities include the construction of roads, water quality control facilities, and transport tunnels,

clearing for facility sites, and the development of the mine pit. Temporary camps, concrete batch plants, and equipment maintenance areas would be required to support these construction activities.

Most of the construction activities result in the disturbance of overburden and bedrock, the use of waste rock, and the aggravation of landslide conditions. Disturbance of overburden exposes topsoil and glacial till to erosive forces, and releases the organic material in muskeg. Blasting, crushing, transporting, and compaction of bedrock and waste rock creates additional sand and silt sized particles. Precipitation runoff would carry much of this eroded and unconsolidated material to adjacent streams. Fine soil, glacial, and rock particles can increase the turbidity and suspended solids levels of the receiving water. Chemical and mechanical weathering of these freshly exposed rock surfaces will be addressed in the operation phase. Decomposition of organics derived from the disturbed muskeg and topsoil can result in an increase in the receiving stream's total organic carbon (TOC) and nutrient concentrations, and a reduction in dissolved oxygen levels (Appendix E, Section III).

Construction of the transport tunnels and development of the mine pit would result in the release of intercepted groundwater. In general, groundwater from the mine pit area exhibits considerably higher levels of total dissolved solids (TDS), alkalinity, calcium, sulfate, and trace metals, and lower dissolved oxygen than surface waters (Appendix A, Table II-2).

Wastewater discharges from the construction support facilities would also occur. Sanitary wastewaters are generated by the temporary camps. Wastewaters from concrete batch plants characteristically have a high pH, and high suspended solids and turbidity levels. Washdown waters and runoff from equipment maintenance areas contain suspended solids, and oil and grease.

Beaver Creek - Preproduction activities that would affect the water quality in Beaver Creek include construction of a wider access road, two interim water quality control facilities, development of the mine pit, and clearing of sites for the mine service area, crusher, blasting compound storage area, and a permanent 330 person camp. These activities would be supported by a temporary 400 person camp, concrete batch plant, and equipment maintenance area.

The interim water quality control facilities would be constructed at the start of the preproduction period in upper Beaver Creek. All drainage from disturbed areas, with the exception of the access road, would be routed through these water quality control facilities. Sedimentation effects from dredge and fill activities associated with construction of road culverts and the water quality control facilities in the Beaver Creek basin will be effectively controlled by the Forest Service's best management practices (BMP). The facilities would be designed to contain the maximum 24-hour wastewater volume generated by the facility and runoff generated from the 10-year, 24-hour precipitation event. During precipitation events exceeding the 10-year, 24-hour event, partial treatment will occur, but the reservoir

capacity is designed to safely pass larger precipitation events. In addition, the facilities would be required to meet effluent limitations stipulated in a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES and BMP requirements have not yet been finalized, but maximum allowable suspended solids concentrations would likely be in the range of 20 to 30 mg/l for storms up to the 10-year, 24-hour event. Based upon these design criteria, sediment and particulate organic material concentrations caused by all construction and mining related activities other than roads would be effectively controlled. The suspended solids concentrations below the facilities would not be greater than 20 mg/l during normal operations, and the increases in TOC, nutrient, and trace metal concentrations would be minor. Before the water quality control facilities are completed, however, short-term increases in suspended solids can be expected from erosion in Beaver Creek downslope of disturbed areas. Because the entire disturbed area represents only 15 percent of the total Beaver Creek drainage basin, these short-term increases in sediments would be minor.

Before the permanent lower Beaver Creek water quality control facility is completed, the treated wastewaters from the support facilities would be discharged into Beaver Creek. Sanitary wastewater from the temporary camp would be discharged to a drain field. Wastewaters from the concrete batch plant would have to be treated to comply with NPDES permit requirements, or the plant would have to be operated in a zero discharge mode. Wastewaters from the equipment maintenance areas may require pretreatment to remove elevated concentrations of oil and grease before secondary treatment. The combined flow of these treated discharges with the intercepted groundwater is approximately 2 percent of Beaver Creek's average annual flow and about 50 percent of the 7-day, 10-year low flow (Appendix E, Section III-D). Therefore, the predicted increases in BOD, nutrients, TDS, and trace metals of the receiving water would only be noticeable at the point of discharge during periods of low flow. Once the interim water quality control facilities are in operation, the impact of these discharges would be even further reduced by dilution.

Because the changes in water quality parameters mentioned above are minor both before and after the interim water quality control facilities are in operation, the overall impact to Beaver Creek during construction is considered insignificant.

Blossom River, No. 1 Creek, Raspberry Creek, and No. 3 Creek - The water quality of these streams would be affected by the widening of the Blossom River access road. Cut and fill activities would induce some landslides, resulting in potentially very significant impacts as discussed in the subsection presented below entitled "Intermittent During Construction and/or Operations." Compared to landslide effects, increases in sediments due to sheet and gully erosion during construction would be minor if proper construction techniques are employed. Very minimal dredge and fill activities would take place in the Blossom River and other tributaries crossed by the access road. Therefore, other than landslide effects discussed separately, the impacts to water quality would be insignificant.

The water quality of the Blossom River and the Wilson River downstream of the confluence of these two streams would be affected by the construction of an access road and instream activities for the supplemental water supply facility. Water quality impacts from the construction of the water supply access road and pipeline would consist of short-term sediment increases from rainfall runoff. Good construction practices, such as those currently required by the Forest Service for construction of the bulk sampling access road (Appendix E), will restrict these impacts to the insignificant level. Very little dredge and fill activity would be necessary. As discussed above, Blossom River water quality impacts, other than landslide effects, would also be insignificant. Water quality effects from landslides are discussed in the "Intermittent" section.

Tunnel Creek - Water quality would be affected by the construction of an access road, water quality control facility, and reservoir dam, and clearing of sites for the mill, power plant, and a permanent 325 person camp. Wastewaters from a concrete batch plant and temporary 900 person camp, along with intercepted groundwater from the conveyor and tailings tunnels would also occur. Because the entire disturbed area represents only 3 percent of the total Tunnel Creek drainage basin, the short-term increases in sediments would be minor. The minor amount of fill required for construction of the Tunnel Creek access road bridges would not significantly affect the Tunnel Creek sediment load. The combined flow of treated discharges with the intercepted groundwater is approximately 3 percent of Tunnel Creek's average annual flow and about 85 percent of the 7-day, 10-year low flow (Appendix D, Section III-D). After the water quality control facility is in operation, water quality modifications would be further reduced by dilution. Overall, the impact to water quality would be insignificant.

White Creek - The water quality would be affected by the construction of an interim water quality control facility, a portion of intercepted groundwater from the mine pit, and stockpiling of overburden. No significant dredge or fill activities would be necessary except for construction of the water quality control facility. Due to the fact that the increases in sediments would be short term and adequately controlled after the water quality control facility is in operation (approximately two months), and the effects of overburden disturbance are considered minor, the overall impact would be insignificant.

Project Operations Phase

In addition to the impacts discussed in the construction phase, the water quality of project area streams and groundwater could also be affected to varying degrees by the chemical weathering and potential microbiological leaching of waste rock, and the spills of chemicals, fuels, or tailings due to a truck accident, tank leakage, or pipeline break. Those impacts associated with spills are discussed in the "Intermittent" section. Cooling water and wastewaters from the power plant would either be recycled through a storage tank for use in the milling process or discharged at a very low rate into the thickened

tailings. Wastewaters from the mill would be recycled internally or discharged with the tailings; therefore, no discharges from either of these facilities to Tunnel Creek are anticipated during normal operations.

Mass balances to project the receiving water quality at various points downstream from each water quality control facility were performed for four operation scenarios in the affected drainage basins (Appendix E). Resulting water quality was calculated for both interim and final water quality control facility scenarios for the proposed project at both the 7-day, 10-year low flow and the average annual flow. Maximum operational development in the drainage basins upstream of the water quality control facilities was assumed for determining the flows used in these scenarios (Appendix D). A proposed characterization of influent to water quality control facilities from disturbed areas (Table 4-3) was developed for these mass balances based on U.S. Borax's commitment to comply with NPDES effluent limitations at the point of discharge, Alaska Receiving Water Quality Standards at the boundaries of approved mixing zones, and the following assumptions:

1. During the exploratory and bulk sampling phases of this project, periodic analyses of mine adit drainage were performed from July 1981 through December 1983 to comply with NPDES permit monitoring requirements. The results of these water quality analyses were compiled and are presented in Appendix A, Table II-2 as the mine drainage effluent characterization. This data base was used for determining the typical characterization of mine pit drainage and waste rock runoff for the EIS.

2. Acidic mine waters with elevated concentrations of trace metals result from the chemical and biological oxidation of sulfide minerals present in the rock exposed during the mining process. Approximately 900 million tons of waste rock would be removed from the mine pit area and disposed of in the White/Hill Creek and Beaver Creek drainage basins. Early chemical analyses of potential ore samples from the center of the Quartz Hill portion of the mine pit revealed that 4 out of 13 samples had the potential to produce sulfuric acid. A total of 3 composite samples of some acid-producing and some acid-consuming ores were also analyzed. Of these 3 composites, 2 still exhibited an overall acid-producing potential (U.S. Borax 1980). However, the suggested confirmatory tests using <u>Thiobacillus ferroxidans</u> to determine whether the ore samples are conducive to microbiological leaching were not performed. In 1983, U.S. Borax performed additional chemical analyses of ore samples from the Quartz Hill and Bear Meadow adits. This time the Quartz Hill samples were not acid-consuming, while the Bear Meadow composite and five out of six rock types that made up the composite were acid-producing. Confirmatory tests with bacteria were performed on these five rock types and the composite with negative results. Even the rock type with the highest theoretical net acid production did not support <u>Thiobacillus ferroxidans</u> activity (U.S. Borax 1985a).

TABLE 4-3

COMPARISON OF DISTURBED AREA CHARACTERIZATION TO APPLICABLE FEDERAL AND STATE WATER QUALITY STANDARDS

	Parameters (mg/l or as noted)	Disturbed Area Characterization	NSPS 1/ Effluent Limitations	ADEC Receiving Water Quality Standards 2/	State Drinking Water Standards
1	pH, units	7.00	6.0 - 9.0	6.5 - 9.0	-
2	Total Dissolved Solids	500.00	-	3/	1,000.0
3	Hardness (as $CaCO_3$)	200.00	-	-	-
4	Alkalinity (as $CaCO_3$)	150.00	-	>20.0	-
5	Oil and Grease	12.00	-	-	-
6	Total Organic Carbon	17.00	-	-	-
7	NH_3 and Org Nitrogen (as N)	2.60	-	-	-
8	Nitrate Nitrogen (as N)	4.00	-	<10.0	45.0
9	Total Phosphorus (as P)	0.13	-	-	-
10	Silica (as SiO_2)	18.00	-	-	-
11	Sulfate (as SO_4)	240.00	-	<200.0	500.0
12	Chloride	7.00	-	<200.0	500.0
13	Calcium	100.00	-	-	-
14	Suspended Solids	4/	30.0/20.0	-5/	-
15	Dissolved Oxygen	7.00	-	>7.0	-
16	Arsenic 6/	0.014	-	0.360/0.190	0.05
17	Cadmium	0.004	0.10/0.05	0.0039/0.0011	0.010
18	Chromium (Hexavalent)	-	-	0.016/0.011	0.05
19	Copper	0.010	0.30/0.15	0.018/0.012	1.0
20	Iron	0.700	-	-/1.00	0.03
21	Lead	0.020	0.6/0.3	0.082/0.0032	0.05
22	Manganese	0.490	-	-/-	0.05
23	Mercury	-	0.002/0.001	0.0024/0.000012	0.002
24	Molybdenum	1.100	-	-/-	-
25	Nickel	-	-	1.4/0.16	-
26	Selenium	-	-	0.26/0.035	0.01
27	Silver	-	-	0.0041/0.00012	0.05
28	Zinc	0.028	1.5/0.75	0.12/0.11	5.0

1/ See Appendix E, Table II-A.
2/ See Appendix E, Section II-B and Table II-3.
3/ Increase in TDS shall not exceed one-third of the concentration of the natural condition of the body of water.
4/ Suspended solids concentration was back-calculated for each mass balance scenario so that the discharge would be 20 mg/l.
5/ Standard is no measureable increase above background. Assumed to be 30/20 mg/l for calculation purposes.
6/ Trace metal concentrations for disturbed area characterization is dissolved portion only, for NSPS effluent limitations the concentrations represent total metals and for ADEC standards the concentrations are based on total recoverable metals. See discussion in Appendix E, Section III-F, for explanation of how these different concentrations were found to be comparable in this analysis.

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However, because these were ore samples, even though they have very similar mineral characteristics as waste rock, there was some doubt at that time whether they represented the acid-producing characteristics of the projected waste.

In order to correctly address this concern about acid leaching, U.S. Borax performed both chemical analyses and modified confirmatory tests with the bacterium on representative samples of waste rock from the area to be mined. Even though the chemical analyses indicated that several samples had theoretical net acid-producing potential, the results of the biological tests confirmed that acid drainage should not be produced from the first seven years' production of waste rock (U.S. Borax 1985b).

Evaluation of the waste rock will be an ongoing process as the mine is developed. The waste rock plan proposed by U.S. Borax in Appendix A, Section II.A.3 could adequately prevent any extensive chemical or microbiological leaching of the waste rock, if the portion of acid-producing rock types is relatively small compared to the total rock formation. The various control methods outlined in the plan, specifically blending and reducing permeability, have been successfully implemented in similar mines (Pelletier 1984). Therefore, based on these latest bacteriological tests and the proposed waste rock plan, it was assumed that there would be no noticeable decreases in pH or increases in trace metal concentrations in the runoff from the waste rock disposal areas compared to what has been measured in the mine adit drainage.

3. The concentrations of residual blasting compounds (ammonium nitrate and fuel oil) in the mine pit drainage and waste rock runoff were assessed in Appendix E, Section III-C and found to be minor. Using the maximum values for nitrate nitrogen and oil and grease in the mine adit drainage characterization more than adequately covers their predicted contribution.

Tables 4-4 and 4-5 present the resulting water quality during the peak of mining operations for Beaver Creek and Blossom River, and Hill Creek and Keta River, respectively, in comparison to baseline conditions and to proposed Alaska Receiving Water Quality Standards. Because the outfall discharges comply with the NPDES effluent limitations and most of the proposed ADEC standards before dilution, the changes to downstream water quality overall are within acceptable limits.

Turbidity, which is a required measure under Alaska Receiving Water Quality Standards, is not included in the mass balances. The factors that contribute to turbidity are highly variable (colored substances, sediment size, and concentration). In addition, turbidity is not well correlated with suspended sediment (Appendix E). Therefore, accurate prediction of turbidity is not possible. Turbidity will be monitored and mitigated according to state permits.

TABLE 4-4

RESULTING WATER QUALITY CHARACTERISTICS OF LOWER BEAVER CREEK AND THE BLOSSOM RIVER DUE TO DISCHARGES FROM THE FINAL BEAVER CREEK WATER QUALITY CONTROL FACILITIES 1/

Parameter (mg/l or as noted)	Outfall 001 Discharge 2/	Beaver Creek Existing Water Quality Mean 3/	Projected Water Quality At Low Flow		Blossom River Existing Water Quality Mean 4/	Proposed Alaska Receiving Water Quality Standards 5/6/	Projected Water Quality At Average Flow	
			Beaver Creek At Falls	Blossom River Below Beaver Creek Confluence			Beaver Creek At Falls	Blossom River Below Beaver Creek Confluence
Suspended solids	20.0	5.2	17.9	1.3	1.0	7/	17.9	1.7
Temperature, °C	No change	5.6	No change	No change	5.2	<15	No change	No change
Dissolved oxygen	7.5	11.7	8.1	11.7	11.8	>7.0	8.1	11.7
Total dissolved solids	452.2	22.0	392.5	24.6	19.2	8/	390.5	33.6
pH, units	7.0	6.1	6.5	6.1	6.1	6.5-8.5	6.6	6.1
Total hardness, as $CaCO_3$	181.0	9.7	157.2	13.4	11.3	-	156.4	16.9
Alkalinity, as $CaCO_3$	136.1	11.4	118.8	10.3	8.7	>20.0	118.3	13.0
Oil and grease	10.8	0.3	9.4	0.8	0.7	9/	9.3	1.0
Total organic carbon	15.6	2.5	13.7	8.0	7.9	-	13.7	8.1
NH_3 + org nitrogen, as N	2.4	0.4	2.1	0.4	0.4	-	2.1	0.5
Nitrate nitrogen, as N	3.61	0.06	3.11	0.13	0.09	<10/-/45	3.10	0.21
Total phosphorus, as P	0.13	0.08	0.12	0.03	0.03	-	0.12	0.03
Silica	16.5	3.4	14.7	3.3	3.1	-	14.7	3.5
Calcium	90.4	3.5	78.3	5.1	4.0	-	77.9	6.9
Sulfate	216.7	6.5	187.5	6.2	3.5	<200/-/500	186.5	10.6
Chloride	6.4	1.0	5.7	1.0	0.9	<200/-/500	5.6	1.1
Arsenic	0.013	<0.005	0.012	<0.005	<0.005	0.360/0.190/0.05	0.012	<0.005
Cadmium	0.004	<0.002	0.004	<0.002	<0.002	0.0039/0.0011/0.010	0.004	<0.002
Copper	0.009	<0.003	0.008	<0.003	<0.003	0.018/0.0012/1.0	0.008	<0.003
Iron	0.645	0.145	0.575	0.086	0.079	-/1.0/0.03	0.573	0.098
Lead	0.019	<0.010	0.018	<0.010	<0.010	0.082/0.0032/0.05	0.018	<0.010
Manganese	0.442	0.009	0.382	0.014	0.009	-/-/0.05	0.380	0.023
Molybdenum	0.992	<0.020	0.857	0.038	<0.026	-/-/-	0.853	0.058
Zinc	0.026	0.009	0.024	0.014	0.014	0.12/0.11/5.0	0.024	0.014

1/ See Appendix E for assumptions concerning water quality mass balances.
2/ From Mass Balance in Appendix E.
3/ Data source Table 3-5, Station BV-QC-1890.
4/ Data source Table 3-5, Station BL-QC-1894
5/ For the trace metal criteria that are determined by the water's hardness, calculations were based on the hardness of 100 mg/l as $CaCO_3$.
6/ Where multiple values are presented, the first value represents the acute toxicity level, the second value represents the chronic toxicity level, the third value is the drinking water standard.
7/ Standard is no measurable increase above background. Assumed to be 30/20 mg/l for calculation purposes.
8/ Increase in TDS shall not exceed one-third of the concentration of the natural condition of the waterbody. Assumed to be <500 mg/l for calculation purposes. Drinking water standard is 1,000 mg/l.
9/ See Appendix E, Table II-1, Parameter 10.

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TABLE 4-5

RESULTING WATER QUALITY CHARACTERISTICS OF LOWER HILL CREEK AND THE KETA RIVER DUE TO DISCHARGES FROM THE FINAL HILL CREEK WATER QUALITY CONTROL FACILITIES 1/

Parameter (mg/l or as noted)	Outfall 003 Discharge 2/	Hill Creek Existing Water Quality Mean 3/	Projected Water Quality At Low Flow		Keta River Existing Water Quality Mean 4/	Proposed Alaska Receiving Water Quality Standards 5/6/	Projected Water Quality At Average Flow	
			Hill Creek At Falls	Keta River Below Hill Creek Confluence			Hill Creek At Falls	Keta River Below Hill Creek Confluence
Suspended solids	20	1.0	17.7	3.5	1.3	7/	17.7	4.6
Temperature, °C	No change	4.8	No change	No change	5.6	<15.0	No change	No change
Dissolved oxygen	10.9	11.9	11.0	11.5	11.6	>7.0	11.0	11.5
Total dissolved solids	114.4	11.9	101.9	30.7	19.6	8/	101.9	36.1
pH, units	7.0	6.1	6.6	6.3	6.3	6.5-8.5	6.7	6.4
Total hardness, as $CaCO_3$	47.0	6.3	42.0	12.8	8.2	-	42.0	15.0
Alkalinity, as $CaCO_3$	40.4	11.3	36.9	15.7	12.4	>20.0	36.9	17.3
Oil and grease	3.2	0.8	2.9	0.5	0.1	9/	2.9	0.7
Total organic carbon	5.5	2.4	5.1	3.1	2.8	-	5.1	3.3
NH_3 + org nitrogen, as N	0.9	0.5	0.9	0.5	0.4	-	0.9	0.5
Nitrate nitrogen, as N	0.94	0.13	0.84	0.25	0.16	<10/-/45	0.84	0.30
Total phosphorus, as P	0.11	0.10	0.11	0.10	0.10	-	0.12	0.10
Silica	5.8	2.6	5.4	3.2	2.8	-	5.4	3.3
Calcium	22.7	2.2	20.2	5.2	2.8	-	20.2	6.3
Sulfate	52.6	2.8	46.5	9.1	3.2	<200/-/500	46.5	11.9
Chloride	2.3	1.0	2.1	1.1	1.0	<200/-/500	2.1	1.2
Arsenic	0.007	<0.005	0.007	0.005	<0.005	0.360/0.190/0.05	0.007	0.005
Cadmium	0.002	<0.002	0.002	<0.002	<0.002	0.0039/0.0011/0.010	0.002	<0.002
Copper	0.004	<0.003	0.004	0.003	<0.003	0.018/0.0012/1.0	0.004	0.003
Iron	0.190	0.055	0.174	0.082	0.068	-/1.0/0.03	0.174	0.089
Lead	0.012	<0.010	0.012	0.010	<0.010	0.082/0.0032/0.05	0.012	0.010
Manganese	0.108	0.007	0.096	0.017	0.005	-/-/0.05	0.096	0.023
Molybdenum	0.247	<0.020	0.219	0.047	<0.020	-/-/-	0.219	0.060
Zinc	0.012	0.008	0.012	0.007	0.006	0.12/0.11/5.0	0.012	0.007

1/ See Appendix E for assumptions concerning water quality mass balances.
2/ From Mass Balance in Appendix E.
3/ Data source Table 3-5, Station HC-QC-1965.
4/ Data source Table 3-5, Station KE-QC-1860.
5/ For the trace metal criteria that are determined by the water's hardness, calculations were based on the hardness of 100 mg/l as $CaCO_3$.
6/ Where multiple values are presented, the first represents the acute toxicity level, the second value represents the chronic toxicity level, the third value is the drinking water standard.
7/ Standard is no measurable increase above background. Assumed to be 30/20 mg/l for calculation purposes.
8/ Increase in TDS shall not exceed one-third of the concentration of the natural condition of the waterbody. Assumed to be <500 mg/l for calculation purposes. Drinking water standard is 1,000 mg/l.
9/ See Appendix E, Table II-1, Parameter 10.

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Beaver Creek - The water quality of this resource would be impacted by access road erosion, runoff from facility sites and waste rock piles, and intercepted groundwater from the mine pit until year 6. The changes in water quality of Beaver Creek, presented in Table 4-4, are due primarily to the high concentration of total dissolved solids. Even though the TDS concentration of the water quality control facility discharge is below the Class 1A(i) ADEC standard of 500 mg/l, Beaver Creek would still experience a 20-fold increase over its pristine baseline value. Increases of similar magnitude would also occur for the associated dissolved constituents, calcium and sulfate, and correspondingly, for hardness and alkalinity. A mixing zone approximately 2,000 ft downstream from the outfall just above the lower Beaver Creek falls would be required for sulfate. With a hardness of 180 mg/l as $CaCO_3$, the resulting Beaver Creek water would be considered "hard." However, the higher alkalinity would provide the creek with greater buffering capacity. All of the trace metals except manganese would be diluted within the mixing zone below the proposed ADEC standards. Due to these increases over the pristine baseline conditions, the impact to Beaver Creek is considered moderately significant (refer to Appendix E, Section III-I for further details).

Blossom River - The water quality would be affected by the input of resulting water quality from Beaver Creek, and erosion of the access road. The changes in water quality of the Blossom River from the final water quality control facility discharge into Beaver Creek, presented in Table 4-4, are so minimal that they fall within the range of natural variation.

Erosion of the proposed access roads would cause a long-term increase in suspended solids concentrations and turbidity in streams downslope of the road. Estimates of sedimentation rates to affected streams are presented in Appendix E and are based on studies performed in the Olympic Peninsula in Washington State, where precipitation patterns and average basin slopes are very similar to those in the project area (Cederholm et al. 1981). Because the Olympic Peninsula roads were located on a different type of substrate, these estimates are considered to be an upper bound of potential effects from the project roads. Based on this comparison, sediment loads would increase 6 percent in the Blossom River, an insignificant impact.

No. 1 Creek, Raspberry Creek, and No. 3 Creek - The water quality of these water resources would be affected by erosion of the Blossom River access road. Because No. 1, Raspberry, and No. 3 creeks have steep gradients, sediment would be quickly washed into the Blossom River and water quality impacts would be insignificant.

Wilson River - The water quality of the Wilson River would be affected by erosion of the Blossom River access road. Wilson River sediment loads would increase about 4 percent due to the Blossom River access road. This is considered an insignificant impact.

Tunnel Creek - The water quality during the operations phase would be affected by emergency overflow of the process area water quality control facility, and erosion of the Tunnel Creek access road and

facility sites. The process area water quality control facility receives runoff from the mill, power plant, and camp sites, the small waste rock piles, and intercepted groundwater from the conveyor and tailings tunnels. After sedimentation, the bulk of this water would be pumped up to the process water tank to be used in the milling process. Therefore, the water quality control facility would be operated in a zero discharge mode and only excess water from a storm greater than the 10-year, 24-hour design event would be discharged on an emergency basis to Tunnel Creek. Changes in water quality due to mill and power plant operation are, therefore, not anticipated. Possible changes to water quality due to a shutdown are addressed in Section 4.1.5.3.

The sediment load in Tunnel Creek due to road erosion would increase by 12 percent (Appendix E). This is considered a moderately significant impact to water quality.

White Creek and Hill Creek - The water quality of these two creeks would be affected by runoff from the overburden stockpile, the waste rock disposal areas, a portion of the mine haulage roads, and intercepted groundwater from the mine pit. The interim water quality control facility is in operation on White Creek for only 14 years; after the Hill Creek water quality control facility goes into operation, White Creek would become buried under waste rock and no longer exist. Therefore, the following discussion is limited to Hill Creek.

The changes in water quality of Hill Creek, presented in Table 4-5, are similar to those discussed above for Beaver Creek. Even though Hill Creek has lower baseline concentrations than Beaver Creek, undisturbed runoff contributes 79 percent dilution so that there is only a 10-fold increase in TDS and associated dissolved constituents. Due to these increases over the pristine baseline conditions, the impact to Hill Creek is considered moderately significant.

Keta River - The water quality would be affected by the inflow of resulting water quality from Hill Creek. Because the changes in water quality of Hill Creek are only moderate and the increased dissolved constituents would be adequately diluted by the Keta River, the resulting water quality changes below the confluence would be within the range of natural variation. Therefore, the impact to the Keta River is considered insignificant.

Intermittent During Construction and/or Operations

Research on logging roads in steep terrain shows that significantly more sediment is contributed to streams from landslides than from sheet or gully erosion of roadbeds and cut and fill slopes (Cederholm et al. 1981). Landslide potential would generally be greatest during the first year following construction, and would generally decrease in subsequent years. Before construction begins, the Forest Service will issue a special use permit that specifies required erosion control measures. These measures will likely be similar to those in the current special use permit for access road construction as presented in part in Appendix E.

A detailed analysis of the probability and impacts of chemical, fuels, or tailings spills related to truck transport and pipeline operations is presented in Appendix G, Section 13. Should a major spill occur, high concentrations of the spilled components would be observed several thousand feet downstream of the spill. Elevated concentrations would be detectable for several miles downstream. The magnitude and duration of these concentrations would be a function of the component and amount spilled, existing precipitation and streamflow conditions, location of spill (i.e., into drainage ditch versus directly into stream), and efficiency of cleanup procedures. In general, duration of these impacts is extremely short, persisting from a few hours to a few days. Medium or long-term water quality impacts, assuming proper cleanup, are not expected to be significant as subsequent flushing, dilution, and biodegradation should return water quality to baseline conditions. There would be no impact to freshwater quality from a break in the tailings pipe as the spilled tailings would be contained inside the tunnel, which drains out into a water quality control facility, the contents of which are pumped to the mixing box in the fjord. Water quality impacts from landslides and spills are discussed in greater detail below by water basin.

Beaver Creek - Because there is only one, low-probability landslide zone located along the Beaver Creek stretch of the access road, it is unlikely that debris would reach the creek. If debris did fall into the creek, the increase in sediments due to landslides along the Beaver Creek portion of the access road would be short-term because of the creek's steep gradient and resulting high flushing rates. Therefore, the impact to water quality would be moderately significant.

Due to the short length (1 mi) of the Beaver Creek portion of the access road, the probability of a spill occurring is extremely low and, therefore, the impact to Beaver Creek water quality is considered insignificant.

Blossom River - The Forest Service has determined that approximately 242,000 cu ft (5,330 tons) of landslide material reached the Blossom River during the year following construction of the Blossom River access road (Lyons 1984). Of this amount, about 52 percent by weight is transported as suspended sediment. More than doubling the width of the Blossom River road from 14 ft to 36 ft would cause further instability of the upslope and fill areas. For the purpose of computing potential sediment increases from landslides, it is assumed that the same volume of landslide-induced sediment that resulted from road construction would also occur during road widening. Also, erosion during construction is assumed to be one-half the estimated annual roadbed erosion during the project operation. Total construction-related sediment would be 3,470 tons/yr, a 17 percent increase over the ambient sediment load of 19,850 tons/year, which results in a moderately significant impact.

Based on the statistical information presented in Appendix G on spills, it is probable that one spill of petroleum products or blasting compounds would occur along the Blossom River access road. Because the short-term water quality changes would be major, the overall impact of a spill is considered very significant.

Wilson River - The Wilson River basin would potentially be impacted by the Blossom River access road, including the short access road to the Blossom River water supply facilities. Increased sediment loads in the Blossom River caused by widening of the Blossom River access road were estimated to be 3,470 tons/yr as discussed for the Blossom River basin. This sediment load would be discharged into the Wilson River at the Blossom River confluence and 45 tons/yr would be contributed from erosion along the Blossom River supplemental water supply access road. These sources represent a sediment load increase of less than 7 percent over the ambient Wilson River level of 52,630 tons/yr. This represents a moderately significant impact to the 0.5 mi stretch below the Blossom River confluence. No significant landslides are expected to result from construction of the water supply access road because most of the route is located in the lowland area adjacent to the river.

Tunnel Creek - The occurrence of landslides along the Tunnel Creek access road would be minimal because the majority of the 2-mi route would be located in the lowland area adjacent to the creek.

Due to the relatively short length of the Tunnel Creek road, the probability of a milling reagent spill into the creek from a truck accident along the route is quite low or unlikely during the life of the project. The probability of a fuel oil spill into Tunnel Creek from a pipeline break is also extremely low due to its short length and design specifications.

Postmining Phase

Activities during this period would cause temporary minor increases in sediment, turbidity, and organic material in the adjacent streams due to reclamation-related erosion. After reclamation activities have ceased and vegetation has been reestablished, these water quality parameters should return to baseline.

The proposed waste rock disposal plan, if properly implemented throughout mine operations, should prevent any extensive chemical or microbiological leaching of the waste rock after reclamation. The agencies are aware of the remote potential for acid production, but are responsible for incorporating the appropriate mitigation measures in their respective licenses. Should some remedial action become necessary, it would be handled through the NPDES and Forest Service environmental programs.

4.1.5.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

The construction of a townsite and associated access road would have similar water quality impacts as described for the construction of facilities in Section 4.1.5.2. Runoff from disturbed areas during construction of the town would be routed through water quality control facilities and treated to comply with NPDES permit limitations. Increased suspended solids levels would therefore be minor. Long-term sediment contributions to Wilson Arm from the Bakewell townsite access road would be approximately 1,750 tons/yr. (Appendix E). This would not be a major increase compared to the natural sediment load of Wilson Arm. Increased sediment contributions from the Wilson I or IIa access roads would total approximately 150 tons/yr, representing a minor increase of less than 1 percent over natural Wilson River levels.

The transportation and storage of fuels and chemicals during all phases of a townsite development would expose both the fresh and marine waters of that location to a potential spill. Because the quantity of fuels and chemicals to be used at a townsite are small, the probablility of a spill occurring is extremely low.

The diversion of upper Hill Creek into North Creek would more than double the average streamflow in North Creek, resulting in additional erosion and scouring of the streambed (Appendix D, Table D-8). Slumping or minor landslides could occur where side slopes are undercut. Suspended solids and turbidity levels would be higher in North Creek than existing conditions until the channel morphology adjusts to the higher streamflow. Water quality impacts would be moderately significant in North Creek and in the Blossom River downstream of the confluence with North Creek until the streambed stabilizes, perhaps as long as 10 years. Diversion of upper Hill Creek, however, would reduce the flow by 11 percent that would have to be retained in the Hill Creek water quality control facility or potentially treated.

All other impacts would be the same as discussed in Section 4.1.5.2.

Effluent from the Tunnel Creek housing area, along with runoff from the mill area and housing sites, and intercepted groundwater from the tunnels would no longer be used in the milling process or discharged with the tailings, but instead would be discharged into Tunnel Creek from the water quality control facility. The impact of this discharge, however, would be considered insignificant since Tunnel Creek, close to premining flows with the reservoir not in operation, would provide more than adequate dilution.

4.1.5.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The construction of a wider and longer access road to accommodate the tailings pipeline would have similar water quality impacts as described for the construction of roads in the proposed project.

A major break in the tailings pipe would affect the water quality of Tunnel Creek, but only in the remote case that the spill containment facilities failed. The high suspended solids concentration and turbidity due to the solids portion and the concentrations of trace metals and residual milling reagents in the liquid portion (see Appendix F for estimated concentrations) would greatly affect both the surface and groundwater quality from the point of entry and downstream. Even during high flow periods, there is not a sufficient volume of water in Tunnel Creek to dilute a major input of tailings components to below detection limits before the creek discharges into Wilson Arm. Due to the fact that a pipeline rupture and containment failure is extremely unlikely, the impact to Tunnel Creek is considered insignificant (Appendix G, Section 16).

All other impacts would be the same as discussed in Section 4.1.5.2.

4.1.5.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

The water quality effects associated with the construction, operation, and reclamation of the mill, power plant, and camp sites totaling 210 ac would now occur in the Beaver Creek drainage. However, impacts to water quality below the Beaver Creek outfall and downstream would remain essentially the same as stated in Section 4.1.5.2 for all phases of project development. Impacts to Tunnel Creek would be eliminated, and impacts to all of the other area streams would be the same as stated in Section 4.1.5.2.

If the power plant were in Tunnel Creek, the cooling waters and wastewaters from the power plant would either have to be pumped back up to the mill process tank now at Beaver Creek to be treated and recycled internally, or undergo appropriate treatment to remove excess heat, residual chlorine, and dissolved constituents before it could comply with NPDES requirements for discharge into Tunnel Creek. This additional discharge would only cause minor changes to the water quality; therefore, the overall impact of the power plant remaining in Tunnel Creek would be the same as stated in Section 4.1.5.2.

The 3-mi access road for the tailings pipe from the tunnel to the Boca de Quadra outfall would be revegetated immediately after the pipeline is installed, precluding any significant impacts to Boca de Quadra.

Impacts associated with landslide events and petroleum products spills would be similar to those described in Section 4.1.5.2. Due to the longer haul distance for the milling reagents, statistically 1.5 truck accidents would occur along the route during the life of the project (Appendix G, Table 13-1). Because the short-term water quality changes would be major, the overall impact of a spill is considered very

significant. The moderately significant impacts associated with a major break in the tailings pipe as discussed in Section 4.1.5.4 would affect the Keta River at the point of discharge from the tunnel and downstream.

4.1.5.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

The construction of a wider and longer Blossom River access road to accommodate the tailings pipeline would have similar water quality impacts as described for the construction of roads in Section 4.1.5.2.

Roadbed erosion during the mining period would contribute approximately 1,285 tons/yr of sediment to the Blossom River, a 6 percent increase over existing sediment load (Appendix E). This represents an insignificant impact to the Blossom River.

Impacts associated with landslide events and petroleum products spills would be similar to those defined in Section 4.1.5.2. Due to the longer haul distance for the milling reagents, statistically 1.5 truck accidents would occur along the route during the life of the project. Because the short-term water quality changes would be major, the overall impact of a spill is considered very significant. The moderately significant impacts associated with a major break in the tailings pipe as discussed in Section 4.1.5.4 would affect Beaver Creek and the Blossom River.

All other impacts would be the same as discussed in Section 4.1.5.2.

4.1.5.7 Beaver Creek Mill with On-Land Tailings Disposal

The construction, maintenance, and reclamation of the access roads for the tailings pipelines would have similar water quality impacts as described for the construction of roads in Section 4.1.5.2. Because the pipeline routes would be revegetated, impacts would be short term and, therefore, insignificant.

It is assumed that increased sediment loads from tailings dam construction would be properly controlled through the use of water quality control facilities. Therefore, downstream water quality changes in Tunnel and Aronitz creeks would be minor.

The water impounded behind the tailings dams would be released through the decant structure only after meeting Best Available Technology economically achievable (BAT) and Best Conventional Pollutant Control Technology (BCT) NPDES permit effluent limitations for the "new discharger" category. This water to be decanted would reflect the combined characterization of numerous sources--natural drainage basin runoff and the liquid portion of the tailings slurry input, which includes the liquid phase of the thickened tailings effluent, intercepted groundwater, mill washdown water, and power plant

wastewaters. Table 4-6 presents a comparison of the liquid phase of the thickened tailings effluent with the BAT and BCT effluent limitations. This major component of the tailings slurry complies with the pH and trace metal limitations. The other components could alter the final slurry pH and metal concentrations, but with natural runoff at three times the slurry inflow, adequate dilution to ensure compliance is provided. An analysis of the Tunnel Creek pond operations was performed to determine what effect recycling would have on the resulting metal concentrations in the decanted water. As long as there is a fairly steady input of natural runoff to dilute the pond concentrations, a steady state value below BAT limitations is maintained (Appendix E, Section IV). Proper design and operation of the tailings ponds that provides for adequate settling and layering of the tailings solids would ensure compliance with the suspended solids limitation and prevent seepage into underlying groundwater. Therefore, the impacts to both Tunnel Creek and Aronitz Creek and their groundwater regimes would be considered insignificant.

The moderately significant impacts associated with a major break in the tailings pipeline as discussed in Section 4.1.5.4 would affect the Keta River.

A failure of a tailings dam that released impounded water, which could also carry tailings with it, could have a significant impact on water quality; the degree of significance to the affected river or fjord would depend on size of the failure and other factors.

4.1.5.8 North Meadow Mill with Boca De Quadra Tailings Disposal

The water quality effects associated with the construction, operation, and reclamation of the mill, power plant, and camp sites totaling 210 ac would now occur in the upper Hill Creek drainage, with secondary treated sewage effluent being discharged with the thickened tailings. However, impacts to water quality below the Hill Creek outfall and downstream would remain essentially the same as described in Section 4.1.5.2 for all phases of project development. Impacts to Tunnel Creek would be eliminated, and impacts to all of the other area streams would be the same as stated in Section 4.1.5.2.

The quantity of organic material and dissolved constituents entering Hill Creek and the Keta River due to construction of the Keta River access road would be minor. Long-term roadbed erosion would increase sediment loads in the Keta River by 1,750 tons/yr, or a 7 percent increase over natural conditions, which represents an insignificant impact (Appendix E).

The water quality impacts and their relative magnitudes from the discharge of secondary treated sewage effluent, potential spills, and the construction, maintenance, and reclamation of a town described in Section 4.1.5.3 would now be associated with the Keta townsite.

TABLE 4-6

COMPARISON OF THE LIQUID PHASE OF THE THICKENED TAILINGS EFFLUENT WITH BAT AND BCT EFFLUENT LIMITATIONS

Parameter (mg/l)	Liquid Phase 1/	BAT 2/ (1 day/ 30-day avg)	BCT 3/ (1 day/ 30 day avg)
pH, units	8.7		6.0-9.0
Suspended solids			30.0/20.0
Cadmium	0.015	0.10/0.05	
Copper	0.035	0.30/0.15	
Lead	0.120	0.6/0.30	
Mercury	0.0012	0.002/0.001	
Zinc	0.077	1.0/0.50	

1/ Appendix A, Table II-5. (All trace metals are dissolved portion only.)

2/ Federal Register, Vol. 47, No. 233, Friday, December 3, 1982, p. 54619. All trace metal limitations are expressed in terms of the total metal (the sum of the dissolved and suspended portions), 40 CFR 122.45, Part (c).

3/ Federal Register, Vol. 47, No. 210, Friday, October 29, 1982, p. 49195.

Road-induced landslides and erosion caused by the construction of the Keta River access road could contribute an estimated 1,260 to 1,330 tons of sediment to the Keta River (Appendix E). If this sediment contribution occurred within one year of construction, the annual sediment load to the Keta River would increase by 5.5 to 5.8 percent over the ambient sediment load of 23,000 tons/yr. This would represent a minor impact to the Keta River.

Based on statistical information presented in Appendix G on spills, it is probable that three truck-related spills (milling reagents, blasting compounds, or petroleum products) would occur along the Keta River access road. As the short-term water quality changes would be major, the overall impact of a spill is considered very significant. The probability of a fuel oil spill from a pipeline break is still considered to be extremely low for this alternative.

Reclamation of the existing bulk sampling access road would cause temporary increases in sediment, turbidity, and organic material in the adjacent streams similar to what occurred during construction, but as they would only be short term, the impacts would be insignificant.

4.1.5.9 North Meadow Mill with On-Land Tailings Disposal

The water quality effects associated with the construction, operation, and reclamation of all project facilities except on-land tailings would be the same as those discussed in Section 4.1.5.8.

The impacts to water quality due to on-land tailings disposal as discussed in Section 4.1.5.7 would be similar in extent and magnitude for this alternative. The moderately significant impacts associated with a major break in the tailings pipeline as discussed in Section 4.1.5.4 would affect Beaver Creek, Blossom River, Hill Creek, and Keta River. Rupture of the return water pipe from the tailings disposal pond in Tunnel Creek to the mill would affect Beaver Creek and Blossom River, but would be considered an insignificant impact.

4.1.6 Physical Oceanography

4.1.6.1 No Action

Insignificant impacts on the oceanography of the project area would result from this alternative.

4.1.6.2 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Inner Basin and Commute Option

During the construction phase of the project, impacts to the physical oceanography of the fjords would result from construction of the marine terminal in Wilson Arm, widening of the mine access road, and construction of the marine tailings disposal facilities in Boca de Quadra, including excavation for the mixing chamber and placements of the scour prevention pad at the end of the tailings discharge pipe. These activities would have an insignificant impact on the bathymetry,

hydrography, circulation, and water level fluctuations of the fjord. These construction activities, plus other activities such as road fill and construction of sedimentation impoundments, would produce increases in surface turbidity in the fjords. Turbidity associated with construction activities would involve minor amounts of suspended material, would be transitory and short term in nature, and would have an insignificant impact on the physical oceanography of the fjord.

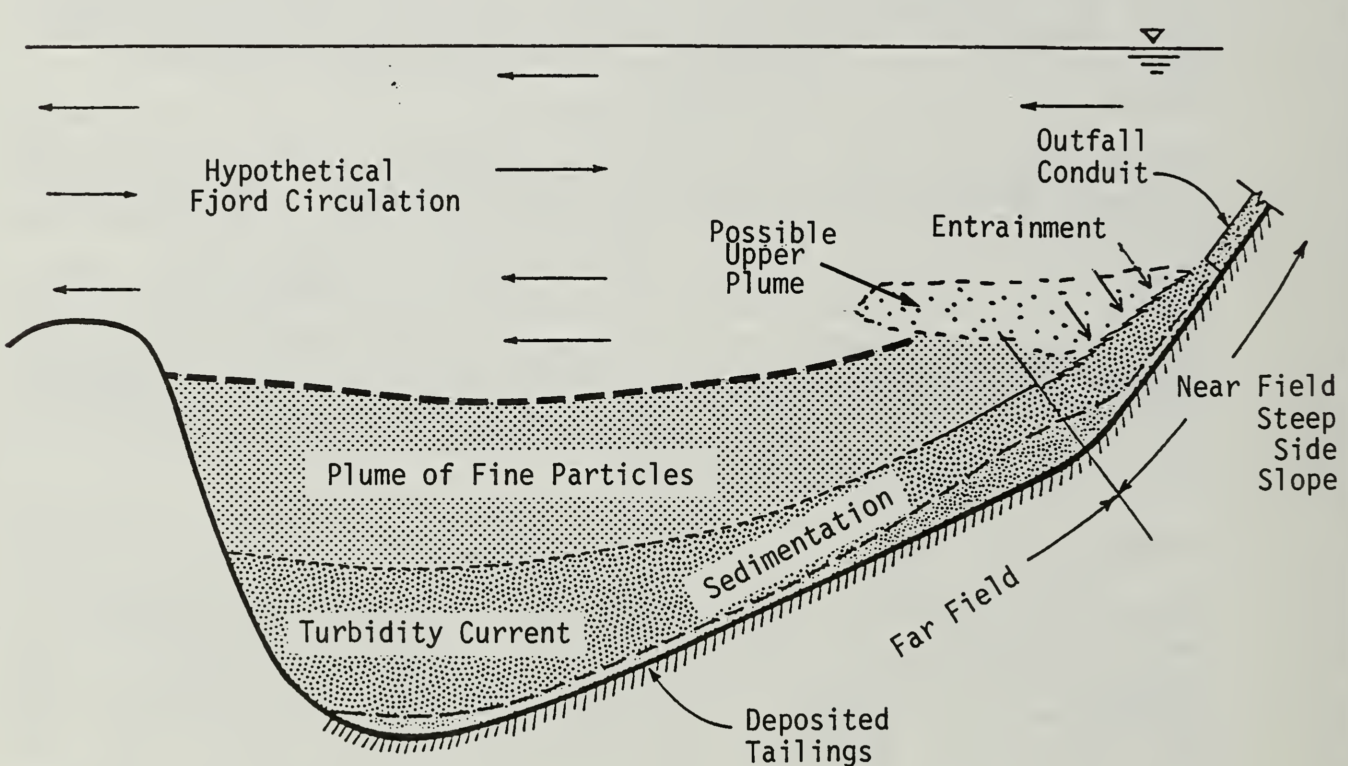
During operation, tailings would be discharged at a location on the west bank of the inner basin, approximately 11,000 ft (3,400 m) downfjord from the Keta River. During the last 50 years of the life of the mine the production rate would be about 80,000 tpd. Total production of tailings during the life of the project would be 1,491 million tons (U.S. Borax 1983b, p. C-1). Tailings, when deposited, would have an assumed density of approximately 100 lbs/cu ft (Rescan 1984a, Appendix A), requiring a storage volume of 29.8 billion cu ft (844.4 million cu m). The tailings slurry would have a specific gravity of 1.39 (U.S. Borax 1983b, p. C-1).

The tailings slurry would flow by gravity from the tailings tunnel, through a series of drop boxes, to the mixing chamber located on the north side of the inner basin. Seawater would be drawn into the chamber from a depth of 120 ft (37 m) (Appendix A, Figure 2-11). Air bubbles entrapped in the slurry would escape from the top of the mixing tank. The slurry-seawater mix would have a higher density than ambient seawater and would therefore flow down the discharge pipe. Discharge would be at the 150 ft (50 m) level. The discharge velocity at the end of the pipe is expected to be between 4 and 12 ft/sec (1.2 to 3.7 m/sec) (U.S. Borax 1983b, p. C-1).

Behavior of Tailings

The tailings discharge would initially act as a jet and the region of the jet is referred to as the near field. (Figure 4-2 depicts the generic regions of tailings discharge.) The near-field behavior of the tailings would be strongly influenced by the outfall configuration, most significantly by bottom slope (Jain and Kennedy 1984, p. vii). As the jet moves away from the discharge pipe, entrainment would mix additional seawater into the plume. The jet would increase in diameter and the velocity of the jet would decrease. Rapid deposition would occur in the near field. Channels would be formed and direct the flow downslope. Material accumulated in the near field would become unstable and slump. Active deposition and slumping would continue in the near field. The net amount of material deposited in the near field would remain the same. After approximately 200 to 300 ft (60 to 100 m) of travel, seawater would have mixed throughout the turbidity current, which would then move under the influence of gravity. A cloud of fine tailings particles above the turbidity current would come under the influence of ambient hydrographic conditions and seek its equilibrium depth. This region, beyond the near field, is known as the far field.

SEDIMENT TRANSPORT AND DEPOSITION



U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-2
REGION OF SEDIMENT TRANSPORT AND DEPOSITION IN A FJORD	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE RYAN (1983a) DATE OCT 83	

Plume behavior would be influenced by the existing configuration of the tailings deposits and would undergo several stages of development as tailings are deposited in the vicinity of the outfall (Jain and Kennedy 1984, p. 33). Prior to deposition of large amounts of tailings near the outfall, the discharge would behave as a jet. The flow would spread rapidly and form a wide shallow plume within a short distance from the outfall. Once tailings deposits have become stable, the plume would behave as a sheetflow. With time, the plume would cut into already deposited tailings and form channels that would contain and direct the flow.

Coarser tailings material would move as a turbidity current in the far field (see Figure 4-2) by the influence of gravity at a rate proportional to the excess of its density over that of the surrounding seawater. Other factors that would influence the movement of coarser tailings material in this region are bottom slope, ambient currents, and the geometry of any channel containing the flow. The finer particles (smaller than 10 microns) would form a broad fines plume extending over the entire width of the fjord from slightly below the outfall depth to the fjord bottom (Findikakis 1983, p. 13).

It is in the far-field region that most of the tailings deposition would occur. Deposition rate of suspended particles is governed by the particle size, shape, specific gravity, and concentration, as well as the velocity of the tailings particles relative to ambient currents. Flocculation would aid the deposition of the finer particles. Larger particles that settle out away from the main axis of the turbidity current would accumulate and form leveed channels. The channels would direct the flow of courser material downslope.

In regions where the bottom slope is less steep, the velocity of the turbidity current would decrease. Where flow velocities decrease abruptly, an internal hydraulic jump would be formed. Turbulence associated with the hydraulic jump will generate a tailings cloud. When the turbidity current reaches an insurmountable obstruction, another hydraulic jump would be formed and the flow become arrested. Arrested currents would occur in three places: (1) where the flow reaches the deepest part of the fjord, (2) where the downfjord flow reaches the base of a sill, and (3) where the flow reaches the upfjord end of the inner basin. Momentum would carry the flow partially up the adverse slope.

Tailings would continue to build up in the bottom of the basin directly below the outfall. During the early phase of the project, this region would be characterized by rapid deposition. Meandering channels would direct the tailings along the path of least resistance. During the first few years of operation, about half of the tailings would move upfjord and half of the tailings would move downfjord. A ridge of tailings would form on the inner basin fjord bottom, opposite from the outfall. With time, this ridge would extend across the fjord bottom, upfjord of the outfall. Most of the tailings would then be directed downfjord. Until the tailings ridge becomes stable, slumping and transport of fines by currents or by diffusion would continue to move tailings upfjord.

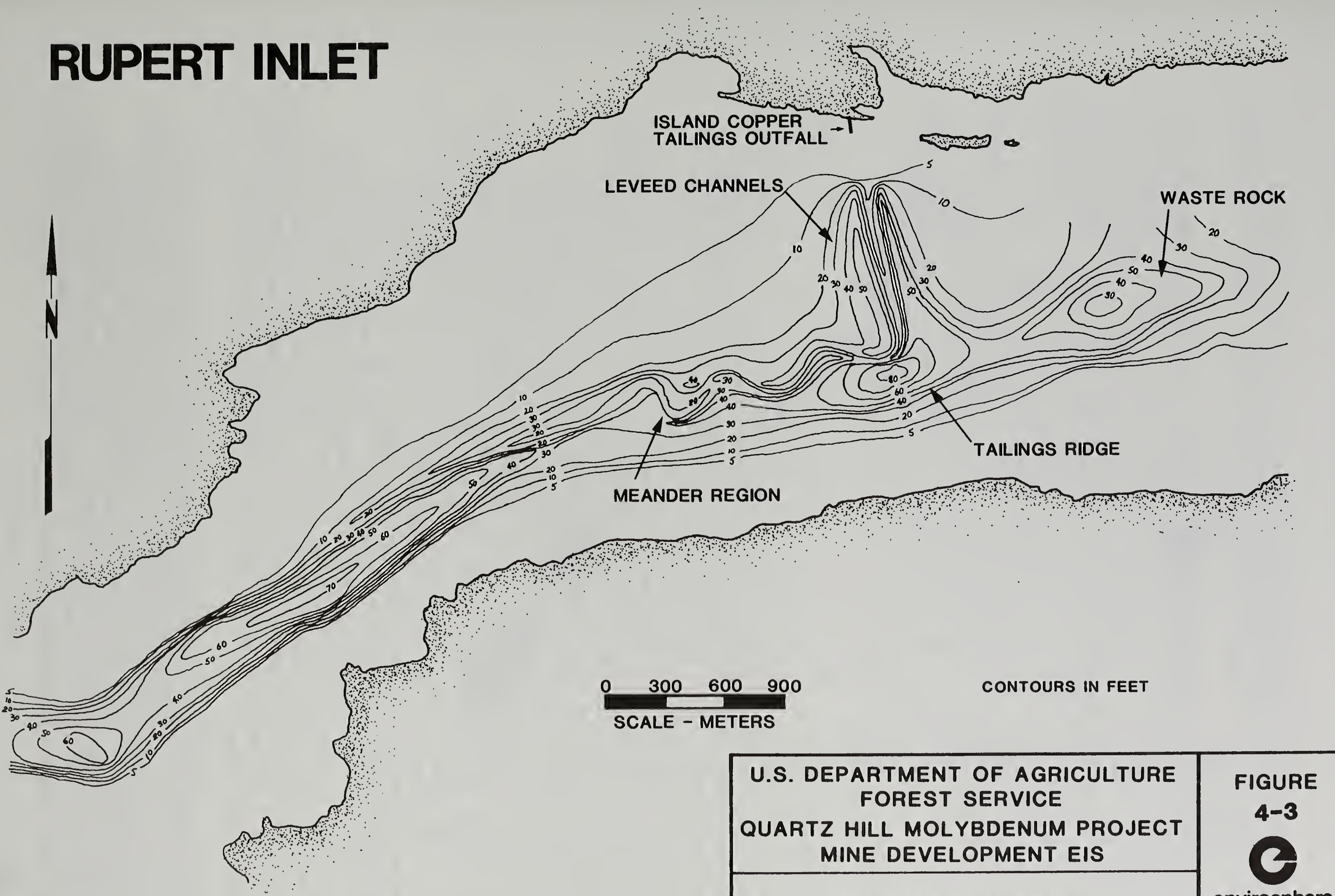
As the ridge of tailings builds, the region of maximum deposition would move outward from below the outfall. As the slope of the ridge also lessens, the leveed channels would meander. When the channel deposits become unstable, the levee would collapse and the channel would shift laterally. The slumped material would continue downslope as a turbidity current. The longitudinal bottom slope may also become unstable and slump. Turbidity currents would carry coarser tailings material down to the deeper reaches of the fjord, while episodic slumping would transport large quantities of material to lower levels. Many of these features are evident from tailings disposal in Rupert Inlet (see Figure 4-3) (Findikakis 1983, p. 115). Rupert Inlet, situated on the northern end of Vancouver Island, is the repository of tailings from the Island Copper Mine. Waste rock from the mine operations is also deposited in the inlet. The Rupert Inlet fjord and the tailings disposal system have been subject to extensive study.

Deposition at the upfjord base of the inner basin sill would continue until the level of tailings nearly reaches the elevation of the top of the sill. Turbidity flows with sufficient momentum would be carried over the sill and into the central basin. Deposition would continue to elevate the fjord bottom until material can freely flow into the central basin and the inner basin bottom slope becomes stable (a stable bottom slope is assumed to be 0.5 percent [U.S. Borax 1983b, p. C-1]). Tailings flowing into the central basin would form leveed channels and would be transported to the deepest part of the fjord.

Modeling Effort

An extensive mathematical and physical modeling program has been undertaken to predict tailings behavior within the Quartz Hill area fjords and the impacts on physical oceanography. This program has included four separate modeling efforts: (1) the near-field physical model by the University of Iowa (Jain and Kennedy 1984); (2) the density current/sedimentation model by Bechtel Civil and Minerals, Inc. (Ryan 1983a, 1985; Findikakis 1983, 1985); (3) the fjord circulation model of the far field by the University of Alaska (Kowalik 1984; Kowalik and Findikakis 1985); and (4) a steady state circulation model used as part of EPA's risk assessment of tailings disposal alternatives (EPA 1988). Figure 4-2 delineates the three generic regions to be modeled and illustrates the important characteristics of the tailings plume. A detailed description of each model is presented in Appendix F.

The objectives of the modeling effort were to investigate the characteristics of the mixing zone near the tailings outfall, predict the depositing pattern of the tailings, and predict the distribution of suspended fines within the fjord. Physical oceanographic field data collected by the University of Alaska (Nebert 1984, 1985) were utilized to gain an understanding of the physical processes within the fjords and used as input to the models. Additionally, a number of specific studies were performed in support of the major modeling efforts. These studies included consolidation tests on tailings samples (Rescan 1984b), buoyancy calculations of the freshwater/seawater/tailings plume



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

DEPOSITION CONTOURS IN RUPERT INLET IN JANUARY 1977.

SOURCE FINDIKAKIS (1983) DATE DEC 83

FIGURE 4-3

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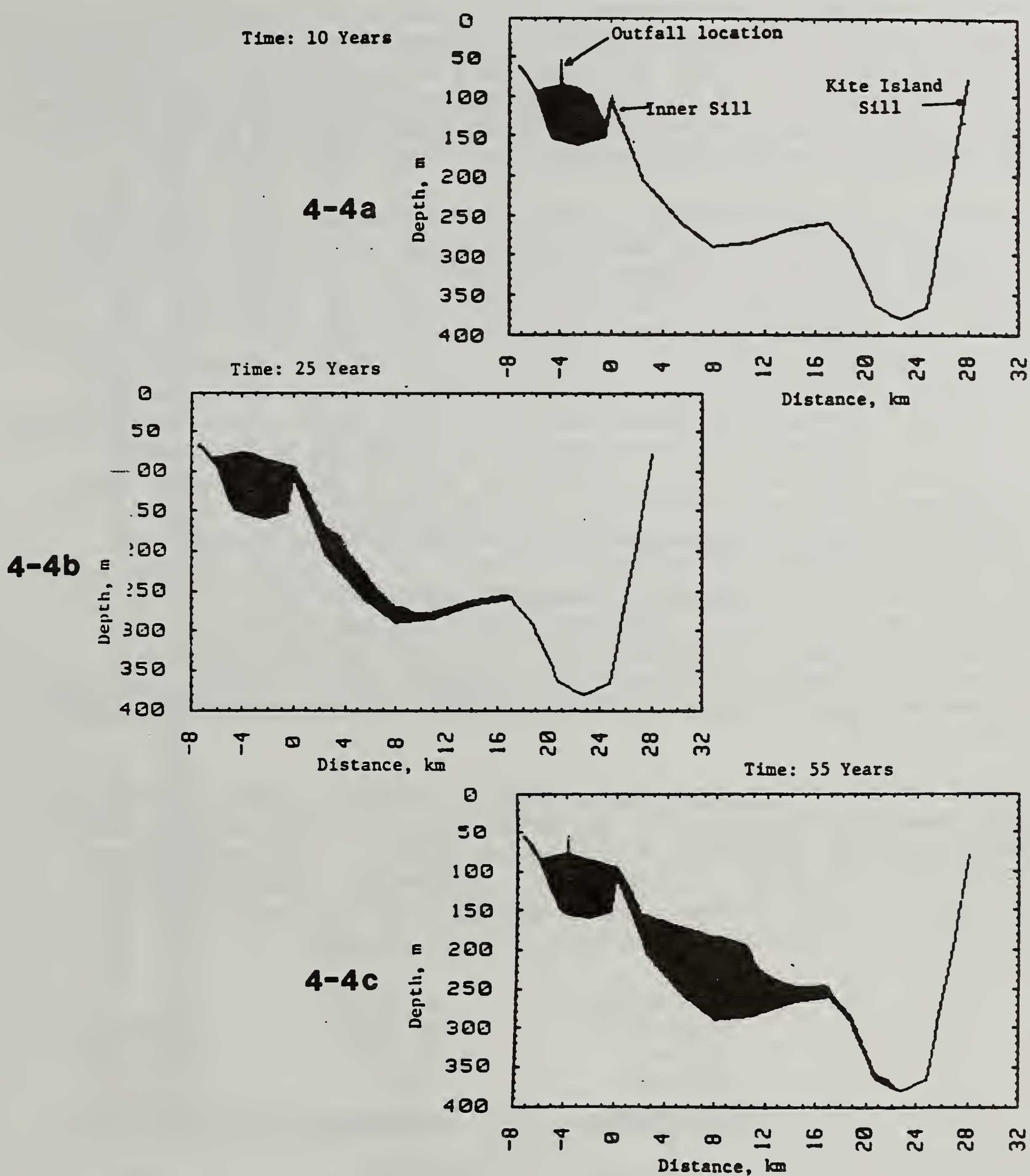
(Bechtel 1984a), and additional calculations on density current behavior and tailings deposition rates (Ryan 1985). Individual models and studies are included in the impacts discussion below.

The circulation and sediment models provide the basis for evaluating the impacts of tailings discharge to the fjord. Impacts to Boca de Quadra and Smeaton Bay were evaluated. The circulation model treated tailings fines as a conservative substance advected by computed currents, producing the predicted distribution of fines. The Boca de Quadra circulation model was run for an 82-day simulation, from June 10 until August 31, 1982. The Smeaton Bay circulation model was run for a 92-day simulation, from June 14 until September 14, 1981. The circulation model was driven by the observed vertical density structure outside the fjord. The measured densities would reflect changes resulting from weather disturbances. Changes to the bathymetry of the fjords, calculated by the sedimentation model, were incorporated into the circulation model for the post-mining simulations. Kowalik and Findikakis (1985) discuss the uncertainties associated with the circulation model.

Bathymetry

Changes in the bathymetry of the Boca de Quadra basins are predicted by the results of the density current/sedimentation model. The model describes the transport of tailings from the end of the near field to the downstream end of the Boca de Quadra middle basin. The model incorporates cross-sectional areas of the fjord as well as basin hydraulic and sediment transport processes, including density current formation, entrainment, internal hydraulic jumps, hindered settlings, coagulation, and slumping of unstable slopes. The model predicts tailings deposition rate and depth versus time as a function of distance from the outfall. The model was successfully calibrated against eight years of data from the Island Copper/Rupert Inlet tailings disposal system. Boca de Quadra tailings disposal was modeled assuming a 40,000 tpd discharge for the first five years of operation and 80,000 tpd thereafter. The tailings outfall was assumed to be on the north side of the inner basin, 4 km upfjord of the inner basin sill. The depth of discharge was modeled as 50 m. The *in situ* compacted density of the tailings was computed by the model as a function of depth of deposition, with the average density being 100 lbs/ft^3. This tailings density is based on consolidation tests performed on Quartz Hill tailings samples (Rescan 1984, Appendix A). Plume dilution 100 m from the outfall was 10:1, based on results of the near-field physical model. The model further assumed a maximum short slope of 5 percent and an average of 0.5 percent slope for long deposition slopes.

After several years of operation, coarser tailings material would be deposited in the deeper parts of the inner basin while the fines would be deposited over the entire basin, probably including the region upfjord of the outfall. After 10 years of operation, approximately 3 percent of the total discharge material would escape over the inner basin sill. Figure 4-4a presents a longitudinal bathymetric profile of the inner basin after 7 years of operation. Over-sill transport of



AVERAGE IN-SITU DRY DENSITY = 100 LB/FT^3

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-4
PREDICTED DEPOSITION PATTERN IN BOCA DE QUADRA – DISCHARGE TO INNER BASIN	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE RYAN (1985) DATE 1985	

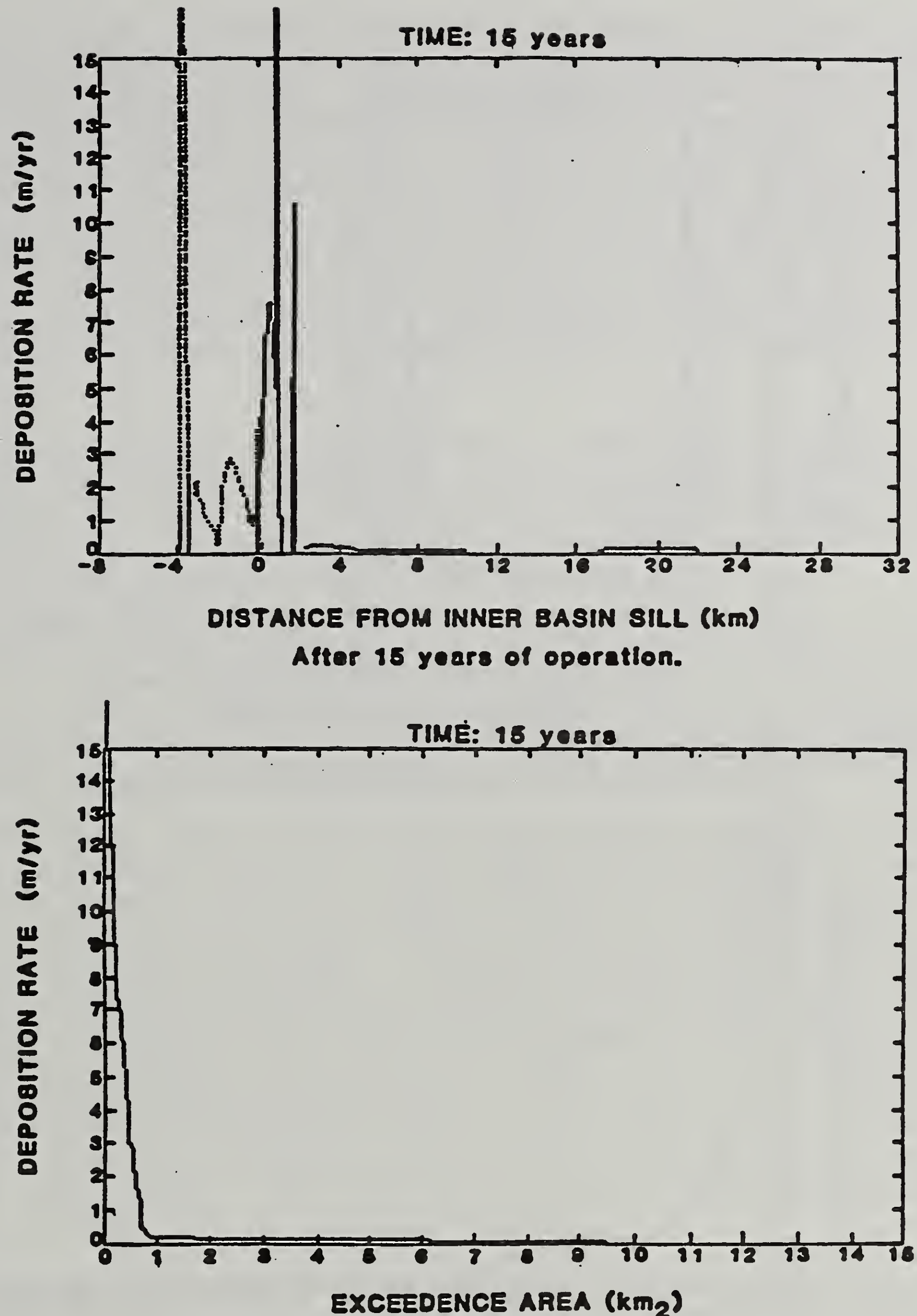
tailings increases to 13 percent of the total discharge after 12 years. After 14 years of operation, further deposits on the inner sill would be unstable and all tailings would be transported downfjord into the central basin. It is reasonable to assume that some tailings fines would continue to be deposited upfjord of the outfall, while the rest of the material would move downfjord over the inner basin sill.

A region of maximum deposition would form downfjord from the outfall. This region of deposition would form a ridge of deposits that would propagate downfjord throughout the duration of the project. After 25 years this ridge would be 50 m thick and would be located at the downfjord bottom of the inner basin sill (Figure 4-4b). At the end of the project this ridge could be 100 m thick and be located 10 km downfjord of the inner basin sill (Figure 4-4c). At that time, 15 percent of the tailings would have been transported to the upfjord foot of the Kite Island sill where deposits 5 m deep would be formed. Deposition rates along the longitudinal axis of Boca de Quadra and exceedance area (area covered by tailings deposits) as a function of deposition rate, are presented for two cases: after 15 years of operation (Figure 4-5a) and after 40 years of operation (Figure 4-5b). The figures may be used to determine the amount of area covered by tailings at any distance from the outfall. Fine materials in the discharge, representing deposition rates much smaller than those presented in Figures 4-5a and 4-5b, would propagate further, reaching the deepest part of the central basin early in the project (Findikakis 1984).

By the end of the project, approximately 318 million tons of material would have been deposited in the inner basin and 1,173 million tons would have been deposited in the central basin. This represents a significant alteration in the fjord's bathymetry. The following decreases in basin volumes, below the depth of the inner basin sill, resulting from tailings deposition can be expected:

Basin	Preoperational Below-Sill Volume (Million Cubic Meters)	Volume of Tailings (Million Cubic Meters)	Decrease in Below-Sill Volume (Percent)
Inner	100	180	100
Middle	4,300	665	15

Assuming a stable slope of 0.5 percent, tailings deposits would reach a height of about 80 m below the surface, in the region of the outfall. The ridge of tailings upfjord of the outfall would be slightly higher. The inner basin bottom would then slope down at 0.5 percent toward the head of the fjord. Tailings fines would continue to be deposited upfjord of the outfall on the steep submarine slope of the Keta River delta throughout the life of the project. It is unclear what the final depth of deposits would be in this region. However, it is unlikely that significant deposits would occur above the depth of the outfall.



NOTE .... INDICATES DEPOSITION PRIOR TO SLUMPING

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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

DEPOSITION RATES AND EXCEEDENCE AREAS FOR BOCA DE QUADRA

SOURCE FINDIKAKIS (1984) DATE OCT 1984

FIGURE 4-5a

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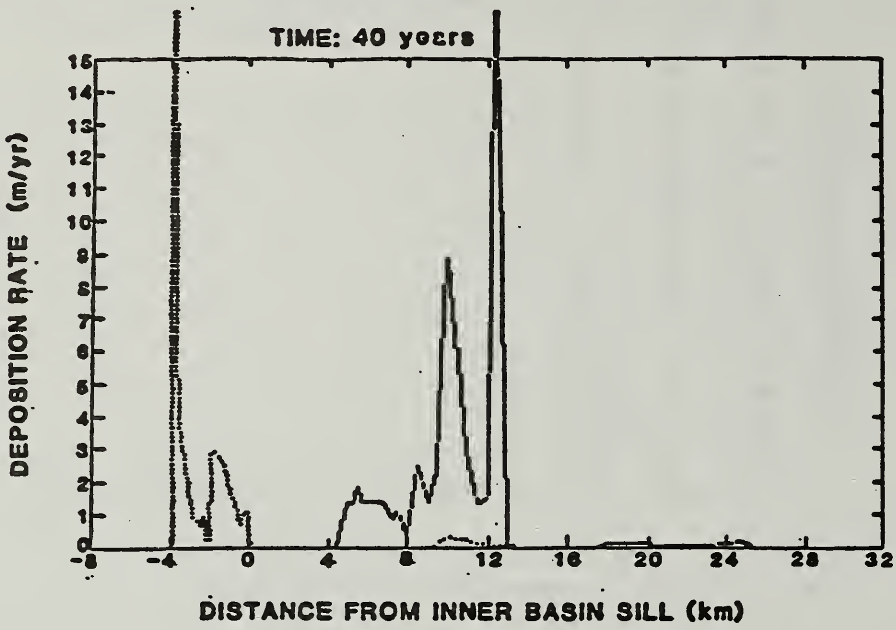
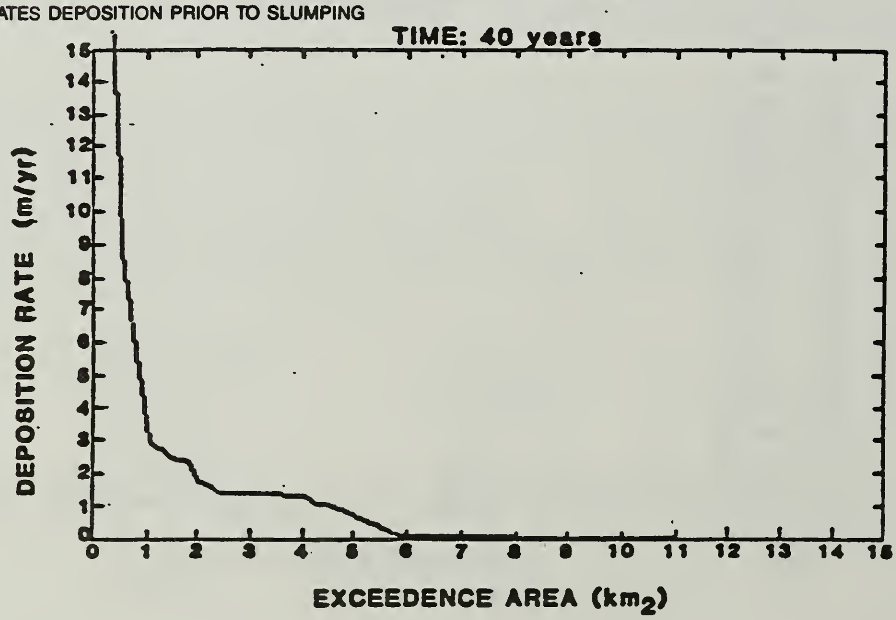


After 40 years of operation.

NOTE .... INDICATES DEPOSITION PRIOR TO SLUMPING



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DEPOSITION RATES AND EXCEEDENCE AREAS FOR BOCA DE QUADRA

SOURCE FINDIKAKIS DATE OCT 1984

FIGURE 4-5b

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Turbidity

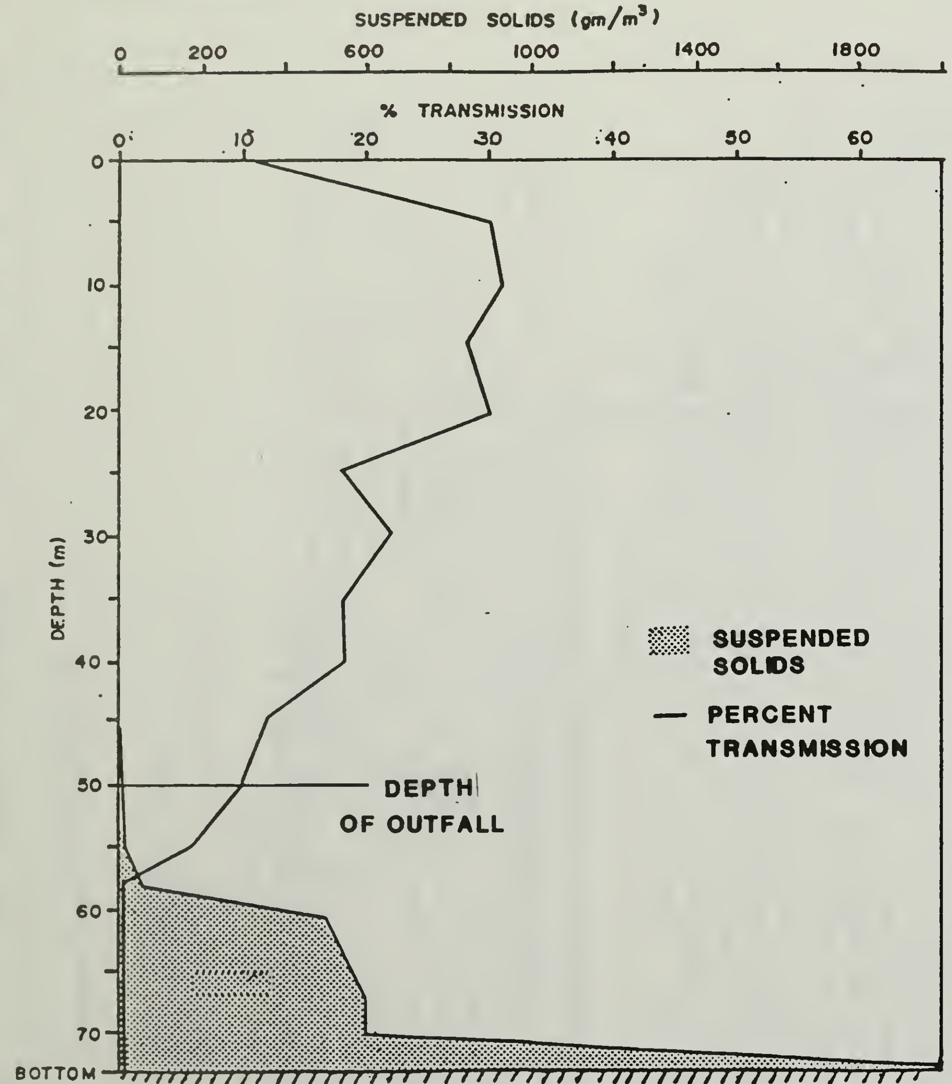
Turbidity of the water column would be impacted in several ways. A dense turbidity current would be formed, which would flow downslope along the fjord bottom. Above this turbidity current would be a plume of fine particles. The material within this plume would consist of the very small tailings particles, 10 microns or less (Ryan 1983a, p. 83). This plume would extend over the entire width of the fjord and at a substantial distance above the bottom. Most of the material in this plume would not extend above the depth of the outfall. Concentrations in the fines plume would range from 5 to 10 mg/l near the top of the plume to the concentration of the turbidity current near the bottom. Average suspended solids concentrations in this plume could be quite high.

Vertical profiles of suspended solids concentration and the percent of light transmission through the water (indicating turbidity) through the fines plume in Boca de Quadra can be expected to resemble those in Figure 4-6. These profiles were obtained from Rupert Inlet during the tenth year of submarine tailings disposal.

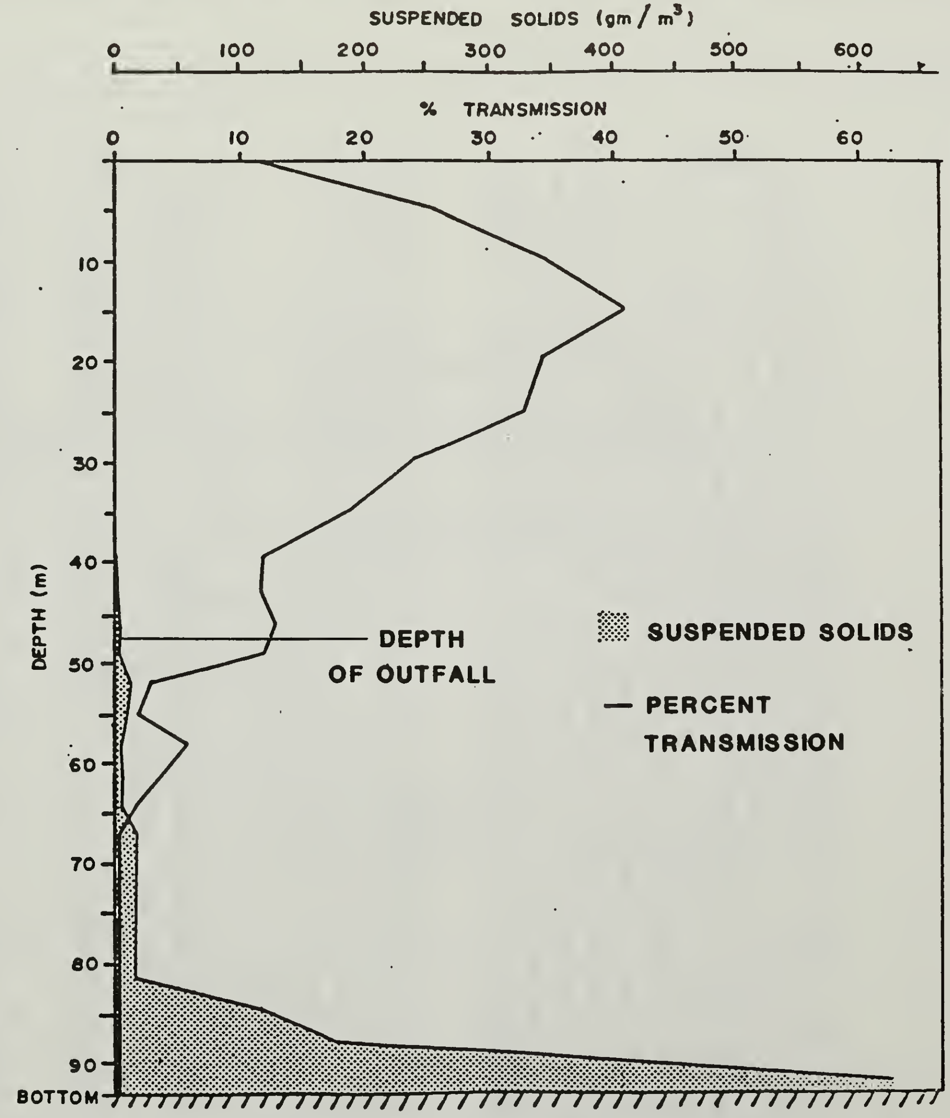
Another possible impact on turbidity may be the formation of an upper level plume. A plume attributed to this mode of discharge (Burling et al. 1981, p. 113) has been observed in Alice Arm, which is the repository of tailings from AMAX of Canada's Kitsault molybdenum mine and is located 80 km northeast of Prince Rupert, British Columbia.

Immediately after the tailings leave the discharge pipe, the larger particles begin to fall. This reduces the density of the upper portion of the plume, which splits away from the turbidity current. This split or upper plume moves to a depth at which its density equals the density of the surrounding water. Increases in bottom slope may enhance the separation of the turbidity current and the upper plume. The upper plume observed in Alice Arm contained about 2 to 8 percent of the daily tailings produced (Burling et al. 1981, p. 44). The upper plume was observed at depths between 200 and 360 ft (60 to 110 m) and extended downfjord approximately 1.5 mi (2.5 km) (Burling et al. 1981, p. 41). The average concentration in the upper plume was 3.6 mg/l (Burling et al. 1981, p. 42). One half of the material in the upper plume precipitated out of the cloud in one day.

Although the formation of an upper level plume is unlikely in Boca de Quadra, the possibility cannot be totally eliminated. Several factors inhibit the formation of an upper plume in Boca de Quadra. Factors that would prevent the formation of an upper level plume would include a limited amount of tailings fines in size categories appropriate for upper level plume formation and laminar flow down well-established channeled deposits. Flocculants added to the tailings would reduce the amount of fine particles available for upper plume formation. Tailings deposits would smooth tailings flow along the fjord bottom, reducing turbulence that could form plumes.



300m downstream from outfall.



1000m downstream from outfall.

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PROFILES OF SUSPENDED SOLIDS IN RUPERT INLET

SOURCE RESCAN (1983) DATE SEPT 83

FIGURE 4-6

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The transport of tailings fines into the fjord has been described by the numerical fjord circulation model developed by the Institute of Marine Science at the University of Alaska (Kowalik 1984). The model describes the unsteady movement of water and the transport of salt and suspended material within the fjord. The model solves the equations of continuity, horizontal momentum, and mass transport in a vertical plane along the fjord centerline. The effects of wind, tidal motions, and bathymetry are considered by the model. Two versions of the model were developed: a tidally averaged model driven by seasonal changes of salinity in the outer basin near the mouth of the fjord and a tide and density driven model driven by seasonal changes in salinity and velocity over a tidal cycle. The results of both versions of the model were compared against salinity and velocity vertical profiles obtained in Boca de Quadra during the 1982 deep water renewal period. The 1982 deep water renewal period, as expressed by temporal and spatial variations in salinity, was reproduced well by the tidally averaged model. The model version driven by tide and density considerations also reproduced the renewal process, but the exchange rate was too slow. The model was used to predict velocity fields and the distribution of salinity and tailings fines within the fjord for several cases before and after the inner basin and parts of the central basin are filled with tailings. The current velocity field computed by the tidally averaged model for the 1982 deep water renewal period (82 days, from June 10 until August 31) is presented in Figure 3-11.

The circulation models have successfully predicted overall patterns of velocity and salinity. However, several features of the models limit their usefulness (Kowalik and Findikakis 1985):

- The coarse grid resolution of the model cannot discern greater details.
- Open boundary conditions only account for the effects of density driven and tidal motions. Other motions such as internal tides and internal flows are ignored.
- Initial velocities in the fjord are set to zero.
- Three-dimensional effects, such as cross-fjord effects, are ignored.
- Turbulent transport and mixing are modeled with constant eddy viscosity and diffusivity coefficients.
- Local vertical accelerations may make the hydrostatic assumption invalid in the areas of the sills.
- More realistic approximations of advective terms could improve modeled predictions.

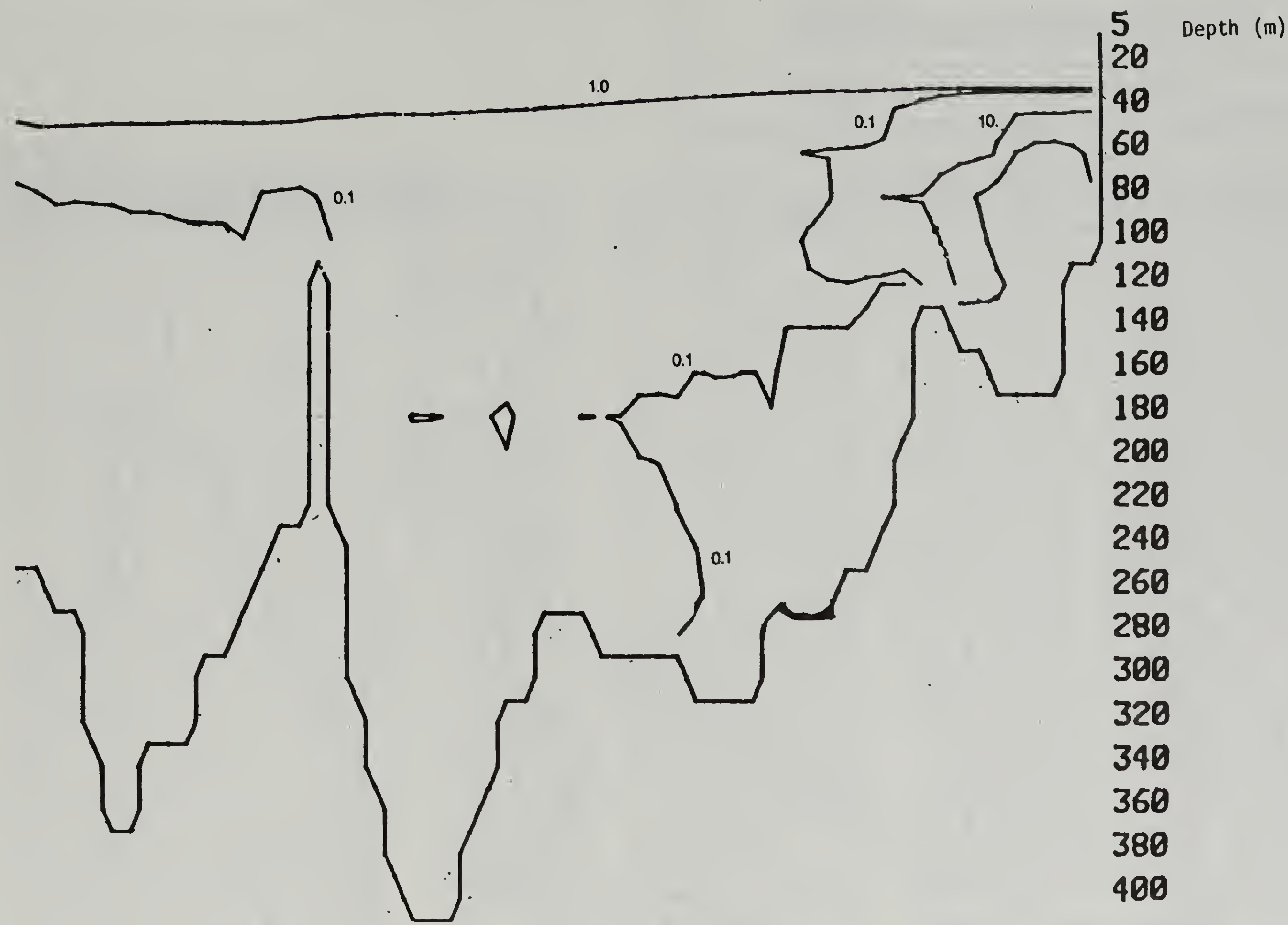
Although there are limitations in the model that should be kept in mind when discussing model results, the circulation model is the best tool available for predicting impacts to the fjord. The model is two-dimensional and has no cross-fjord resolution. Because the horizontal resolution of the model is large, details of the complex processes occurring in the sill regions cannot be incorporated into the model. Distribution of fines predicted by the model is based on a constant source along the fjord bottom and the transport of a conservative substance.

The distributions of tailings within Boca de Quadra as predicted by the tide and density circulation model for the deep water renewal period are presented in Figure 4-7a and 4-7b. The model treated the tailings fines as conserved substances advected by the computed circulation. These figures represent discharge to the inner basin (Figure 4-7a) during the early phase of the project and near the completion of the project, when the inner basin and parts of the central basin are filled (Figure 4-7b). The contours presented in the figures represent percentages of the bottom tailings concentration. Tailings concentrations in the bottommost steady state flow can be expected to be quite high, in excess of 1,000 mg/l. Concentrations above this flow rapidly decrease until the top of the turbulent flow where concentrations of about 40 mg/l can be expected (based on observations in Rupert Inlet where the discharge rate is half of what would be discharged into the fjord at Quartz Hill). Based on modeling results (Figure 4-7b), the top of the plume of tailings fines, at a depth of about 30 m, would have a concentration of 0.04 mg/l, well below the level of background concentrations.

In general, model results show that tailings concentrations would not exceed background levels at the 30 m to 50 m pycnocline depth. Tailings concentrations as predicted by the circulation model for the inner basin discharge case (Figure 4-7a) would be confined primarily to the inner basin. There is little circulation in the inner basin to advect tailings away from the source. The 10 percent concentration level could reach as high as the 40 m depth, above the depth of the outfall. Tailings concentrations above the Kite Island sill and in the outer basin would have a concentration of about 0.1 percent of the concentration of the top of the tailings plume.

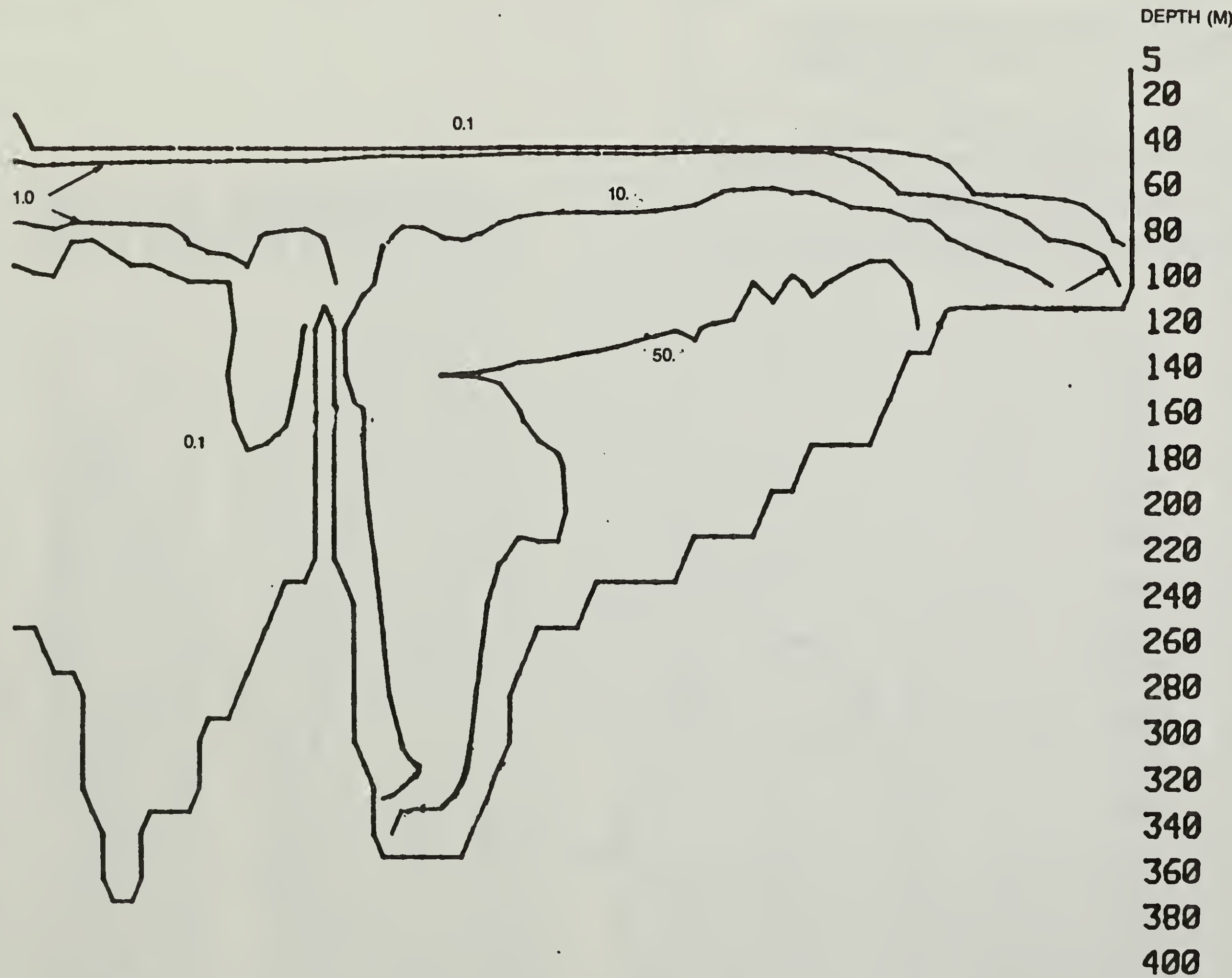
Predicted distributions of tailings concentrations, once the inner basin and parts of the central basin are filled, are presented in Figure 4-7b. In this case, tailings deposition has smoothed the fjord geometry and the flow dynamics. Concentrations of 50 percent of the bottom concentration are mostly confined to the deeper reaches of the central basin.

The circulation model has predicted that tailings fines would remain below the pycnocline and would not impact the surface waters of the fjord. The pycnocline should help prevent vertical movement of fines into the euphotic zone. However, the model does not have the spatial resolution to predict random event-type disturbances that could impact



SOURCE OF TAILINGS CLOUD IS ALONG BOTTOM OF INNER BASIN. CONTOURS ARE EXPRESSED AS PERCENT OF BOTTOM CONCENTRATION. DAY 82 OF SIMULATION.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-7a
DISTRIBUTION OF TAILINGS FINES AS PREDICTED BY TIDE AND DENSITY DRIVEN CIRCULATION MODEL. DISCHARGE TO INNER BASIN, BOCA DE QUADRA.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE KOWALIK (1984) DATE	



SOURCE OF TAILINGS CLOUD IS ALONG FJORD BOTTOM FROM 10 KM DOWNFJORD OF KETA RIVER TO DEEPEST PART OF CENTRAL BASIN. CONTOURS ARE EXPRESSED AS PERCENT OF BOTTOM CONCENTRATION. DAY 82 OF SIMULATION.

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DISTRIBUTION OF TAILINGS FINES AT END OF PROJECT AS PREDICTED BY TIDE AND DENSITY DRIVEN CIRCULATION MODEL.

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE
4-7b

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the surface waters. Surface water impacts would be limited to short-term events and to small areas in the vicinity of the fjord sills. The mechanisms that could move tailings into the near-surface waters are outlined below:

- The beginning of the deep water renewal period initiates vertical mixing within the fjord. During this period, the mid-depth stagnant area in the inner basin and the upfjord portion of the central basin is dissipated. Vertical stratification is weakest in the lower portion of the inner basin during this period. This vertical mixing could transport tailings fines upward.

- Continued downward mixing of less saline water during the winter results in minimal vertical stratification in the lower water column. Tailings could be transported upward at this time when the water column is nearly homogeneous, by vertical movement initiated by internal tides or the commencement of the normal deep water renewal period.

- Internal waves tidally generated on the Kite Island sill have large amplitudes. A breaking internal wave could provide enough energy for vigorous mixing. To date these waves have not been observed to break. Also, calculations of internal wave amplitudes have indicated that the conditions leading to breaking internal waves are not present in Boca de Quadra (Kowalik 1984, p. 48). The nonbreaking internal waves could, however, cause some vertical migration of tailings.

- Surface winds in the inner basin are frequently downfjord. Surface waters moved downfjord by the wind are replaced by mid-depth waters which are moving upfjord most of the year. Tailings fines released into the mid-depth waters could be transported to the surface near the head of the fjord by this replacement mechanism.

- As the inner basin fills, downfjord turbidity currents flow below and counter to ambient currents. Should the two counter currents exceed critical sheer velocities, unsteady flow would develop. During periods of weak stratification, turbulence generated by the unsteady currents could propagate upward. Tailings carried with the turbulent water could also be carried upward, possibly as high as the near-surface waters. This effect should be most pronounced during periods of deep water renewal when high speed ambient currents (up to 40 cm/sec) are present in the sill area. Calculations have indicated, however, that unsteady flow conditions should not transport suspended tailings above a depth of 70 m (Bechtel 1984b).

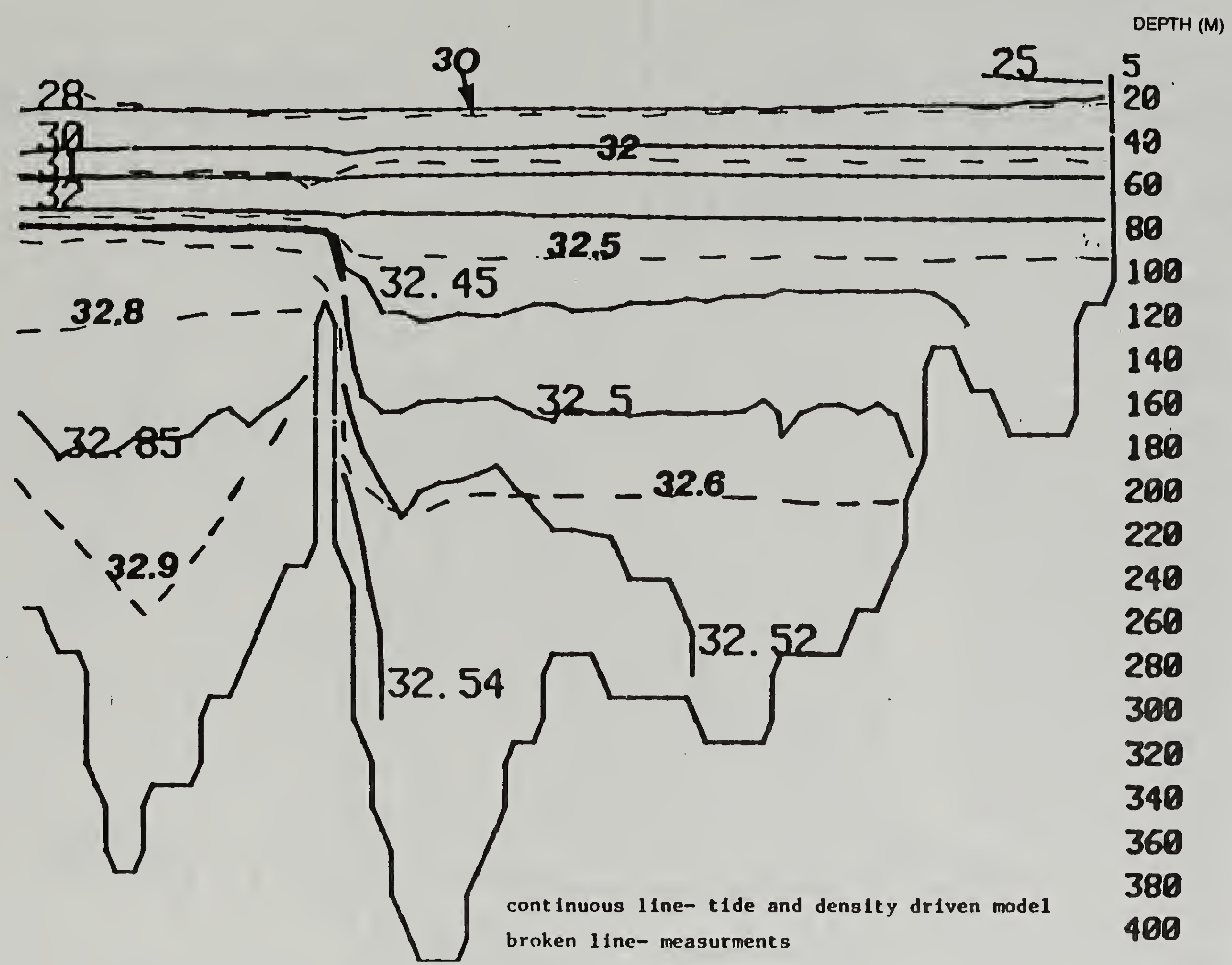
- Most episodic slumping events transport tailings downslope. However, large slumping events could have sufficient momentum to carry tailings material up adverse slopes, especially in the relatively confined inner basin. Turbulence associated with these large events, plus upward movement through weakly stratified water, could bring large amounts of tailings into the near-surface waters.

Except for the slumping events, the above mechanisms operate independently of each other. Impacts to the surface waters of Boca de Quadra from tailings-related turbidity are expected to be related to random events with a low probability of occurrence. Concentrations of tailings in the near-surface waters resulting from the upward movement of fines by the mechanisms described above will be low, probably only slightly above background concentrations. Episodic slumping events operating with any of the other mechanisms listed above could produce the highest tailings concentrations in near-surface waters. However, the area impacted by such events would be small and tailings would rapidly settle out of the water column or be dissipated by surface currents. Because of the nature of these events, their short-term and limited extent, their impact is considered insignificant. Turbidity impacts to the below-sill depth volume of the inner basin are considered significant because of the low volume of the inner basin. Once the inner basin is filled, significant impacts will continue as a consequence of tailings-related turbidity.

Hydrography and Circulation

Impacts to hydrography and circulation within Boca de Quadra have been predicted by the circulation model previously described. The circulation model, however, was used to examine only one period, deep water renewal. The major circulation features of the entire fjord, net near-surface inflows, net sill depth outflows, tidal currents, and deep water renewal, are not anticipated to change. Mean predicted salinities throughout the fjord are compared with measurements made by the University of Alaska in Figure 4-8a. The figure indicates that the tide and density driven circulation model reproduces the process of renewal. However, the modeled exchange rate is too slow. Predicted salinities at the bottom of the central basin are less than actual measured salinities during the period when high density water is entering the basin.

The distribution of salinity as predicted by the tide and density driven circulation model at the completion of the project is presented in Figure 4-8b. As indicated by the model prediction, the smoothing of the bottom geometry has increased the exchange of deep bottom water. Upper water salinities throughout the basin remain essentially unchanged.



SALINITIES IN PARTS PER THOUSAND. PREDICTED SALINITIES ARE FOR DAY 82 OF SIMULATION, CORRESPONDING TO AUGUST 31, 1982, THE DATE OF THE MEASUREMENTS. PREDICTIONS MADE WITH TIDE AND DENSITY DRIVEN MODEL.

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MEASURED AND PREDICTED DISTRIBUTIONS OF SALINITY WITHIN BOCA DE QUADRA.

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE 4-8a

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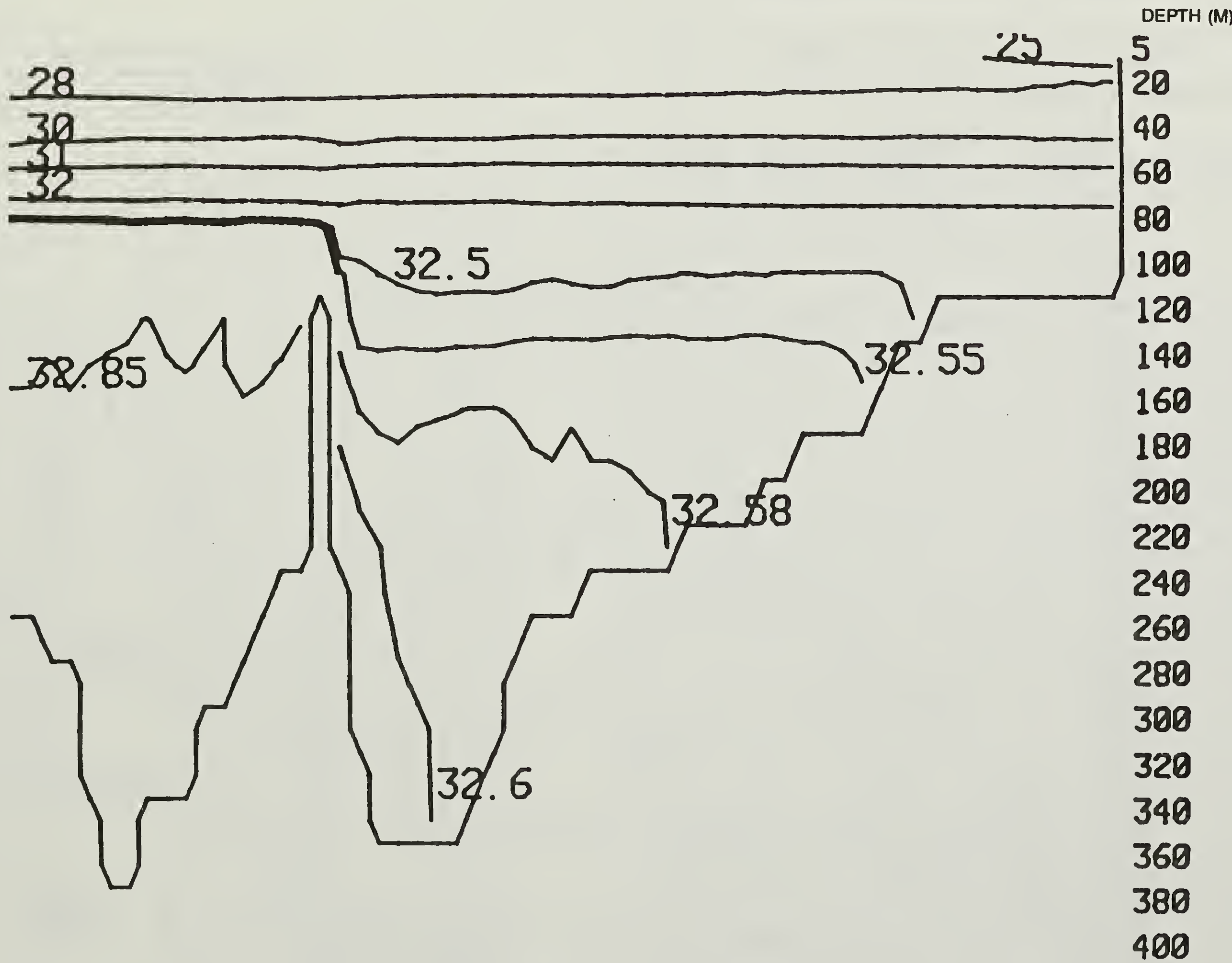

SALINITIES ARE IN PARTS PER THOUSAND. PREDICTION MADE WITH TIDE AND DENSITY DRIVEN CIRCULATION MODEL. DAY 82 OF SIMULATION, DEEP WATER RENEWAL PERIOD.

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PREDICTED SALINITY DISTRIBUTION WITHIN BOCA DE QUADRA AT THE COMPLETION OF THE PROJECT.

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE 4-8b

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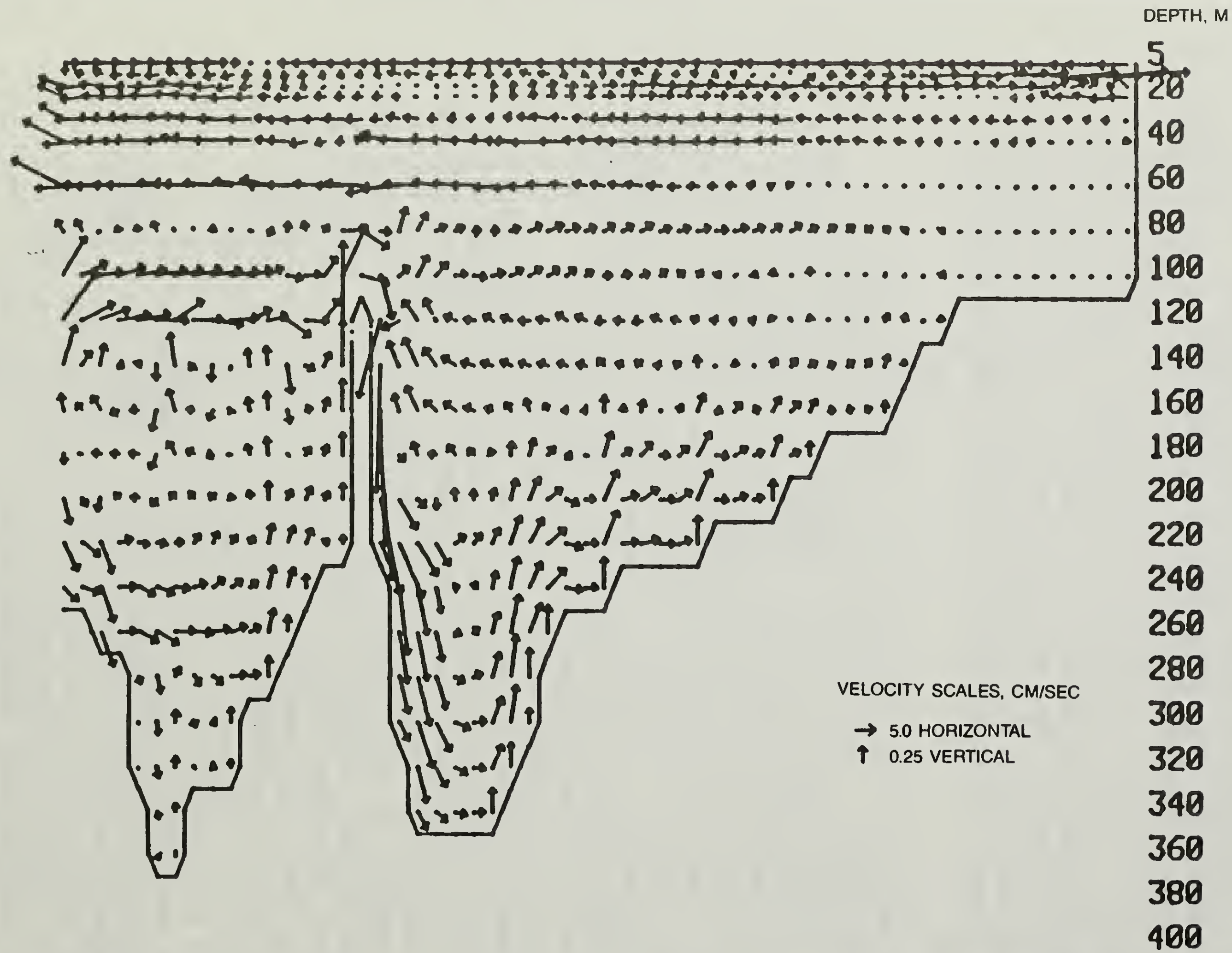
Currents as computed by the tide and density circulation model are presented for premine and postmine deep water renewal periods (Figures 3-11 and 4-9, respectively). Because vertical velocities in the fjord are very small, vertical velocities on these figures have been greatly exaggerated. To enhance vertical resolutions, vertical velocities are exaggerated 100 times more than horizontal velocities.

During the early phase of the project, little modification to the circulation of the fjord would result from tailings disposal. As the below-sill inner basin is filled with tailings, moderately significant impacts to the inner basin circulation would be incurred. Source water for the inner basin sill-depth outflow is the below-sill depth basin waters (Nebert 1984, p. 33). As the basin is filling, the sill depth outflow would decrease and the general circulation of the inner basin would weaken. Thus, based on the modeling results, the flushing rate of the inner basin would decrease as exchange with the central basin is reduced. Tidal currents would continue to provide some exchange with the central basin.

Freshwater requirements of the mill operation also modify the hydrography of the fjords. The tailings slurry would contain 12 million gallons per day (45,000 cu m per day) of fresh water for the 40,000 tpd phase and 24 million gallons per day (90,000 cu m per day) of fresh water for the 80,000 tpd phase (U.S. Borax 1983b, p. 2-7). In addition, the tailings pipeline would occasionally need to be flushed with fresh water. These occurrences would be associated with normal plant shutdown and startup, desanding of the thickeners, and desanding operations on the pipeline or outfall. Proper design and maintenance of the pipeline would ensure that freshwater flushing of the tailings pipelines would not occur more than once every few years (U.S. Borax 1985). The required fresh water would come from Tunnel Creek, supplemented by supplies from intake facilities on the Blossom River. The slurry would be diluted with seawater in the mixing box and would be further diluted by entrainment of large quantities of seawater after discharge. Low salinity water would be carried by turbidity currents into the deeper reaches of the inner basin. It is assumed for purposes of discussion that thermal effects of the discharge would induce the same type of effect discussed below. At large distances from the outfall, settling fines would reduce the density of the upper edge of the plume, which would then become neutrally or positively buoyant (Bechtel 1984a, p. 2). Fingers of the plume would rise and mix convectively with overlying water. The height of rise of those parcels of buoyant water and residual tailings fines released below the pycnocline has been calculated (Bechtel 1984a). These calculations indicate that buoyant parcels of the freshwater plume would approach the surface only during periods of very weak stratification (April). Over 430 vertical profiles of temperature and salinity, collected by the University of Alaska, were examined as part of this study. Only 12 percent of these profiles indicated that parcels of the buoyant plume would be carried above 30 m. All of these profiles were collected in the inner basin. Very little low salinity water would remain in the



DAY 82 OF SIMULATION

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POST PROJECT BOCA DE QUADRA CURRENTS COMPUTED BY THE TIDE AND DENSITY CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE 4-9

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vicinity of the outfall. Bottom salinities of the fjord would be slightly reduced. The amount of tailings transported into the near-surface waters of the fjord by buoyant water parcels would be very small. The events would be brief and very localized.

Major change to the density structure of the fjord is not expected as a consequence of the freshwater requirements of mill operations. Freshwater requirements of mill operations would reduce the amount of fresh water discharged into Wilson Arm by about 2 percent on an annual average basis. This would reduce the vertical stratification in that inlet by weakening the vertical density gradient. Because the amount of fresh water involved is small, the impact to the density structure of Wilson Arm is considered insignificant.

Modifications to the original bathymetry of the fjord and the associated changes to circulation and the water column density structure resulting from tailings disposal would remain after the project is decommissioned. After tailings deposition is terminated, turbidity levels would return to background values and the natural sedimentation rate of about 1 cm/year would resume. Gradually the tailings would be covered with natural sediment and become isolated.

In the event that tailings do not freely flow into the central basin, the outfall location would be moved 22,000 ft to the southwest. Discharge would then be directly into the central basin for the remainder of the project and deposition to the inner basin would cease.

Extension of the tailings outfall to the middle basin would involve some construction-related impacts associated with placement of the mixing chamber, scour pad, outfall pipe, and tailings pipeline. Current plans call for the tailings pipeline to be placed on top of deposited tailings at the bottom of the fjord. Impacts from these activities would be insignificant. With the extension of the outfall to the middle basin, the possibility of a pipeline rupture must be considered. A pipeline rupture would release up to 17,500 cu yd (13,400 cu m) of tailings to the waters of the fjord (see Appendix A, Section E). Turbulence associated with the rupture would quickly disperse the material over a wide area. Coarser tailings material would immediately settle to the bottom. The finer material would spread out in the water, to be eventually dispersed by tidal currents. Tailings fines of the 10 micron size that are not dispersed by surface currents would settle through the euphotic zone (100 ft) in about six days (Bechtel 1984c). Impacts to the physical oceanography of the fjord from a pipeline rupture would be infrequent and of short duration and are, therefore, considered insignificant.

4.1.6.3 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Central Basin and Commute Option

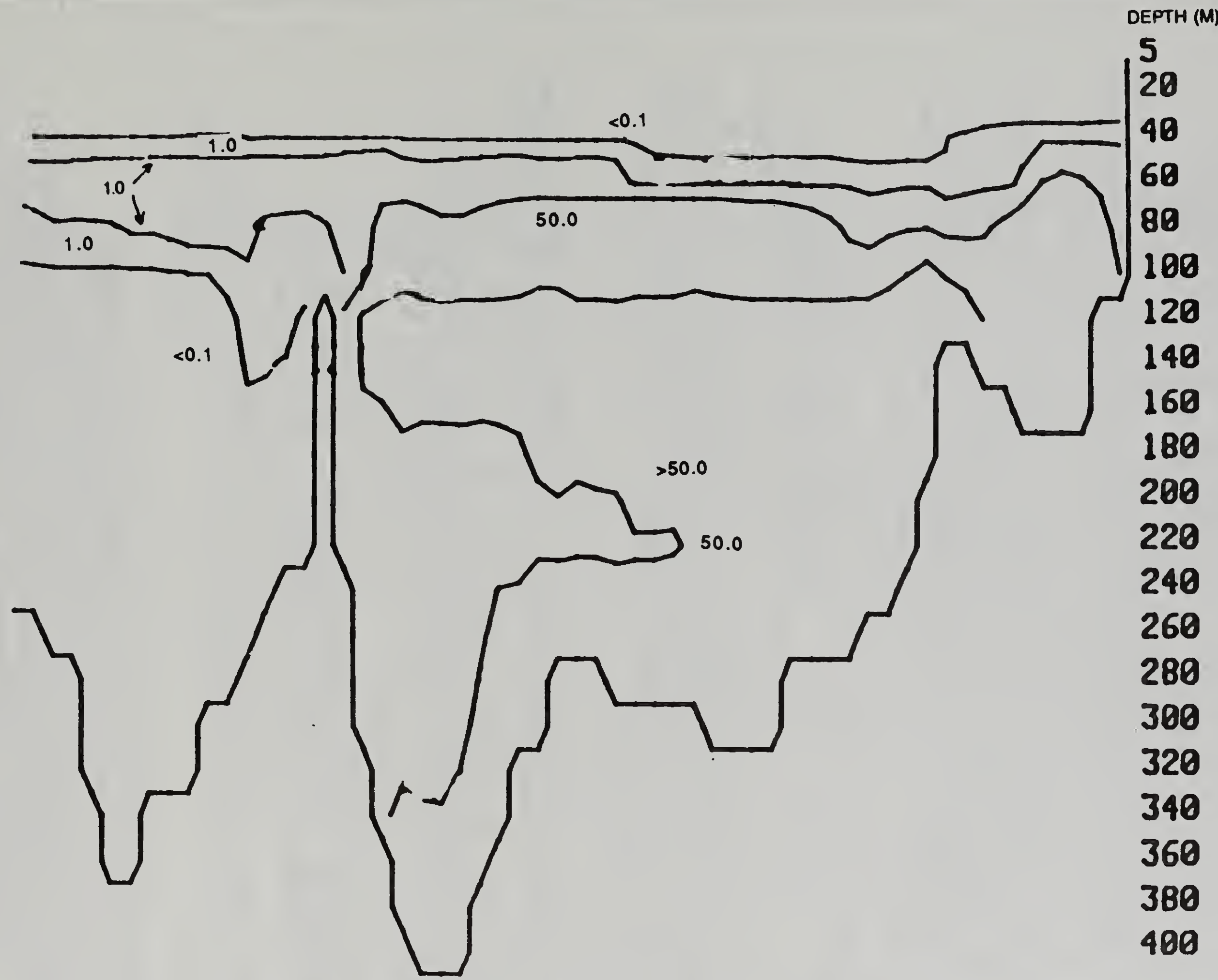
An alternative Boca de Quadra disposal option would be to discharge tailings into the central basin throughout the life of the project. The outfall would then be located on the west bank of the central basin, approximately 28,000 ft (8,400 m) downfjord from the Keta River. Construction phase impacts would be the same as those described

in Section 4.1.6.2 except that they would occur in the designated wilderness area. For this alternative, 1,491 million tons (884.4 million cu m) of tailings would be disposed of in the central basin (U.S. Borax 1983b, p. C-1). This would result in about a 20 percent reduction of the below-sill volume of the basin. Distribution of tailings sediments for a central basin only discharge was modeled and presented in Ryan (1983a). Bathymetric impacts for a middle basin only discharge are very similar to the inner basin discharge case as presented in Figure 4-4c (Ryan 1985). In this figure, the amount of tailings deposited in the inner basin would be distributed over the bottom of the deeper reaches of the middle basin. The below-sill volume of the middle basin would be reduced by an additional 5 percent from the middle basin discharge option. Impacts on the inner basin would be limited to sedimentation of tailings fines that move upfjord over the inner basin sill by tidal currents or by currents related to deep water renewal. The distribution of tailings fines as predicted by the tide and density driven circulation model for a central basin discharge before a significant accumulation of tailings sediment has occurred is presented in Figure 4-10. The distribution of tailings fines at the completion of the project would resemble Figure 4-7b. In this figure, the 0.1, 1.0, and 10 percent contours above the inner basin would rise to between 30 and 60 m. The circulation and hydrological features resulting from 55 years of tailings discharge only to the central basin were not modeled. However, it may be anticipated that circulation and hydrological impacts to the central basin would be about the same as those described for inner basin discharge (see Section 4.1.6.2). The major circulation features of the central and inner basin, net near-surface inflows and sill depth outflows, tidal currents, and deep water renewal are not anticipated to significantly change. Impacts to the inner basin circulation and hydrography would be less for central basin tailings discharge compared to inner basin discharge.

With the exception of random event-type disturbances, tailings fines would remain below the pycnocline and would not impact the surface waters of the fjord. The presence of the pycnocline should help to prevent vertical movement of fines into the euphotic zone. Surface water impacts would be limited to short-term events with limited areal extent. The mechanisms that could move tailings into the near-surface waters are outlined below:

- Stratification is weakest throughout the fjord during late winter and early spring. This would be the most likely time for tailings to be brought into the surface waters by vertical motions associated with internal tides or commencement of deep water renewal.

- Internal waves could cause vertical displacement of tailings, especially in the region of the inner basin sill. However, tailings discharged from the outfall in this region would be moving as a turbidity current downslope and would be less likely to be displaced upward.



SOURCE OF TAILINGS CLOUD IS ALONG FJORD BOTTOM FROM INNER SILL TO DEEPEST PART OF CENTRAL BASIN. CONTOURS ARE EXPRESSED AS PERCENT OF BOTTOM CONCENTRATION. DAY 82 OF SIMULATION.

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DISTRIBUTION OF TAILINGS FINES AS PREDICTED BY TIDE AND DENSITY DRIVEN CIRCULATION MODEL. DISCHARGE TO CENTRAL BASIN.

SOURCE KOWALIK (1984) DATE JUN 84

FIGURE 4-10

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- Strong currents associated with deep water renewal in the Kite Island sill area could scour tailings deposited on the inside slope of the sill and in the very deep portions of the basin. High speed current events occur in this region only during the late summer. About 15 percent of the total amount of tailings produced would reach the deep area where high speed current events have been observed. The possibility that scoured tailings material could reach the near-surface waters is remote because of the small amount of material involved, the infrequent nature of the event, the great depths involved, and the presence of strong stratification in the upper waters.

- Turbidity currents flowing counter to ambient currents could become unsteady if critical sheer velocities are exceeded. The turbulence associated with unsteady currents could carry tailings upward. Calculations have indicated that the flows will not exceed critical shear velocities.

- Episodic slumping events having sufficient momentum could travel up adverse slopes. Turbulence associated with these events, plus upward movement through weakly stratified water, could transport large amounts of tailings upward. With the mode of discharge proposed for the central basin all tailings movement would be downfjord. Any upward movement of tailings related to episodic slumping events would be in the deepest portions of the fjord.

Temporary shutdown of tailings production would result in the cessation of source material for turbidity currents. Tailings fines would slowly settle to the bottom. A vertical decent of 330 ft (100 m) for the 10 micron size particles could require about 18 days (Bechtel 1984d). Episodic slumping of unstable deposited tailings would continue for quite some time.

4.1.6.4 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

This alternative would impact the physical oceanography of Boca de Quadra exactly as described in Sections 4.1.6.2 or 4.1.6.3 depending on outfall location.

4.1.6.5 Tunnel Creek Mill with Wilson Arm Tailings Disposal

With this concept, development would be limited to Wilson Arm/Smeaton Bay. Boca de Quadra would not be affected. Discharge of tailings would be near the head of Wilson Arm in the vicinity of the Wilson Arm wharf. Discharge would be at a depth of 150 ft (50 m).

Bathymetry

The mathematical density current/sedimentation model developed by Bechtel Civil and Minerals, Inc. and previously applied to Boca de Quadra was used to predict tailings deposition patterns in Smeaton Bay (Findikakis 1985). The sedimentation model has been described previously (see Section 4.1.6.2). The model accounted for the additional storage capacity of Wilson and Bakewell arms. Predicted tailings deposition profiles for Wilson Arm/Smeaton Bay are presented in Figure 4-11. During the first 5 years of operation, tailings deposition would occur primarily in Wilson Arm, with small quantities of tailings being transported into the main Smeaton Bay basin. Substantial deposition in the basin upfjord of the deep intermediate sill begins during the 5th year of operation and continues for the next 20 years. After the 20th year of operation, tailings in gradually increasing quantities would be transported over the intermediate sill into the outer subbasin. The outer basin would fill in the following years along with a gradual increase in deposition depths throughout the entire fjord. At operational year 55, the tailings deposits would be 75 m below the surface at the outfall location and would gently slope downward to about 45 m (150 ft) below the top of the outermost sill at a depth of 175 m (580 ft).

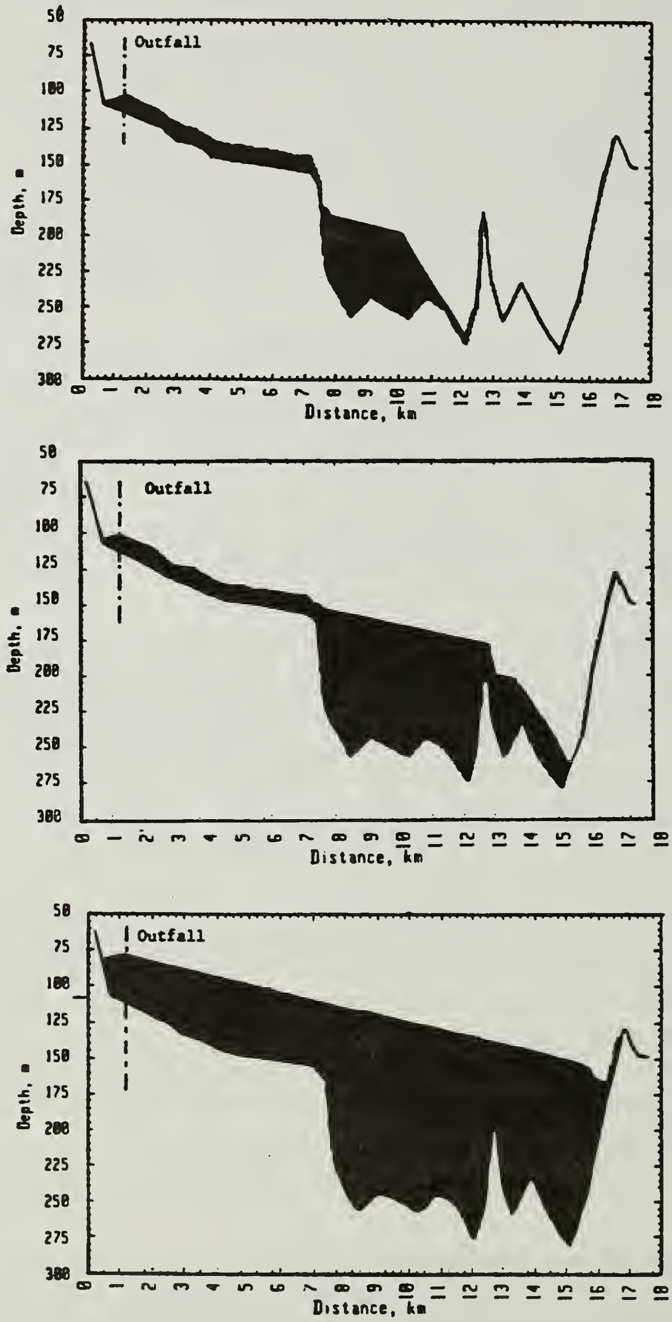
The sedimentation model (Findikakis 1985) was used to estimate the storage capacity of Smeaton Bay. The model was run with a discharge of 80,000 tpd until substantial amounts of tailings escaped over the outer sill (year 70). From this, it was estimated that after 55 years of mine operation between 78 and 82 percent of the below-sill volume of Smeaton Bay would be filled with tailings. This represents a significant alteration of the basin's bathymetry.

Deposition rates and exceedance areas for Wilson Arm/Smeaton Bay, for project years 10, 20, and 55, are presented in Figure 4-12. The figures give the deposition rate as a function of distance from the outfall. Deposition rates for suspended particles prior to slumping and deposition rates after redistribution by slumping are presented on the same figure. Exceedance area (Figure 4-12) is the area covered with new tailings deposits as a function of deposition depth for a particular year.

Turbidity

The fjord circulation model developed by the Institute of Marine Science and previously applied to Boca de Quadra was used to predict the velocity field and salinity and tailings fines distribution within Wilson Arm/Smeaton Bay (Kowalik and Findikakis 1985). Premine and postmine simulations were modeled. Oceanographic data collected from June 11 through September 15, 1981 (97 days) by the Institute of Marine Science were used to drive the model. These data covered the 1981 summer deep water renewal period.

The transport of tailings fines within Wilson Arm/Smeaton Bay was simulated by the tide and density driven circulation model during the early phase of the project and is presented in Figure 4-13. The



(a) YEAR 12

(b) YEAR 25

(c) YEAR 55

U.S. DEPARTMENT OF AGRICULTURE
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QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

PREDICTED TAILINGS DEPOSITION IN SMEATON BAY/WILSON ARM

SOURCE FINDIKAKIS (1985) DATE MAR 1985

FIGURE 4-11

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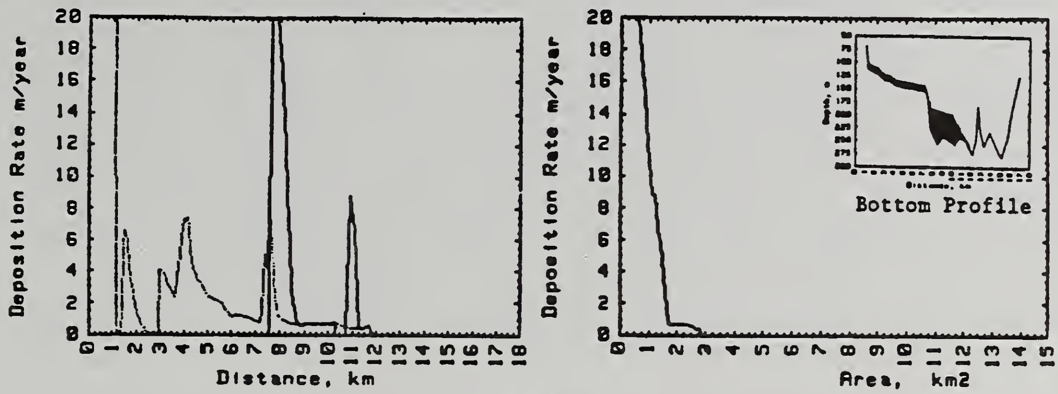
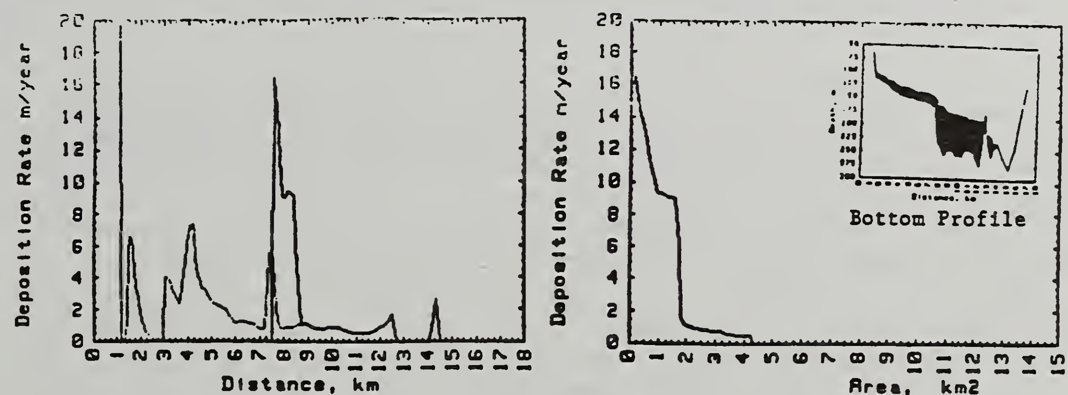
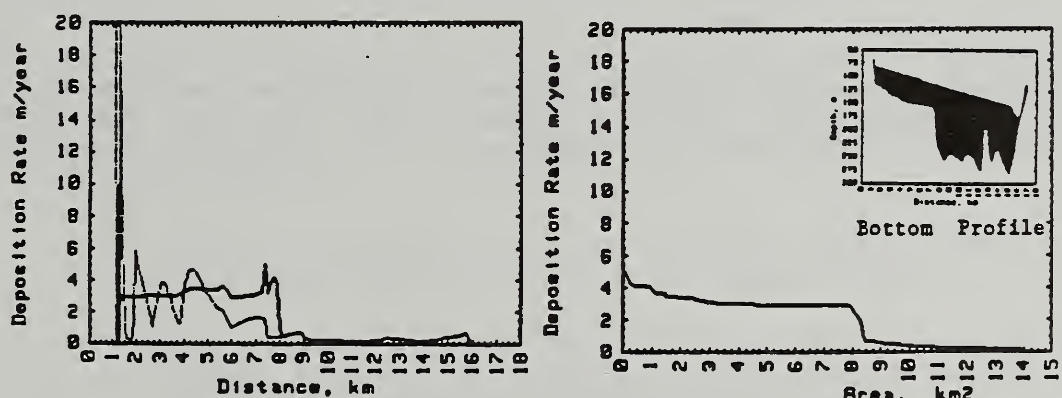


(a) YEAR 10



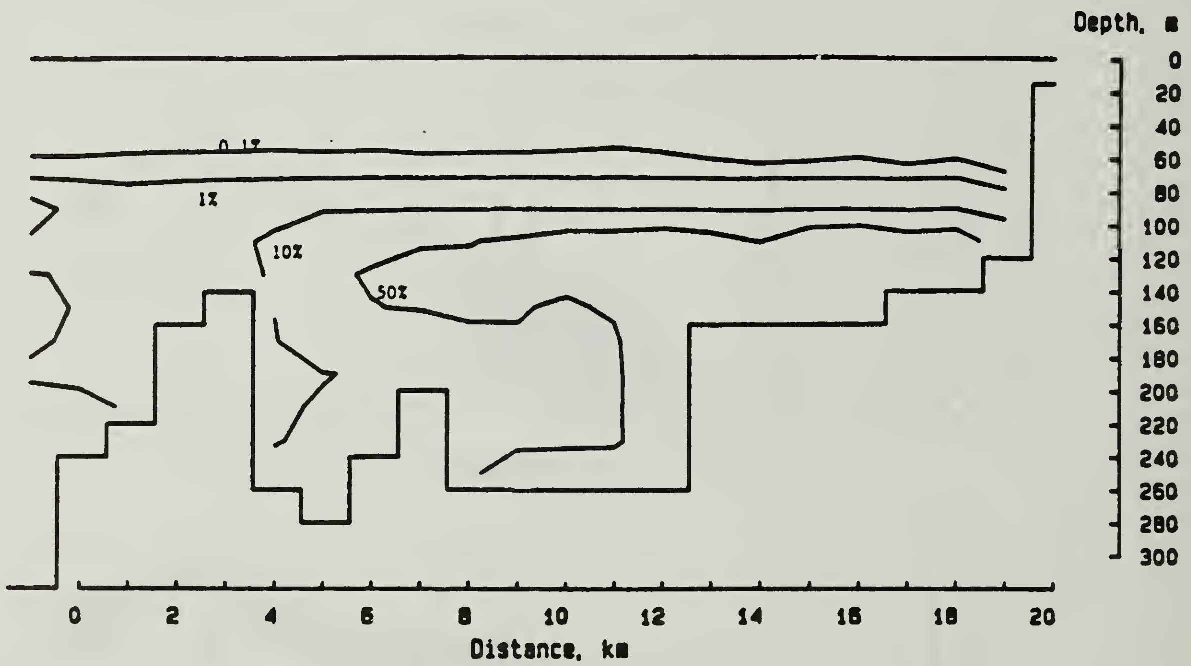
(b) YEAR 20



(c) YEAR 55

NOTE .... INDICATES DEPOSITION PRIOR TO SLUMPING

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-12
DEPOSITION RATES AND EXCEEDENCE AREAS FOR SMEATON BAY/WILSON ARM	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE FINDIKAKIS (1985) DATE MAR 1985	



SOURCE OF TAILINGS IS ALONG THE FJORD BOTTOM FROM THE HEAD OF WILSON ARM TO DEEPEST PART OF THE UPFJORD SUB-BASIN. CONTOURS ARE EXPRESSED AS PERCENT OF BOTTOM CONCENTRATION. DAY 80 OF SIMULATION.

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

DISTRIBUTION OF TAILINGS FINES AS PREDICTED BY THE TIDE AND DENSITY DRIVEN CIRCULATION MODEL. DISCHARGE TO WILSON ARM.

SOURCE KOWALIK AND FINDIKAKIS DATE MAY 85

FIGURE 4-13

envirosphere company
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contours presented in the figure represent tailings concentrations as a percent of the concentration of the bottom turbidity plume. For example, if the concentration at the top of the turbulent density current is 40 mg/l (based on measurements in Rupert Inlet, Figure 4-6, where the discharge rate is half of what would be discharged at Quartz Hill), then the top of the turbidity plume at a depth of about 60 m would have a predicted concentration of about 0.04 mg/l, well below the level of the background concentration. As simulated, the tailings fines are transported slowly toward the outer sill. At the peak of the deep water renewal period (before day 80 of the simulation), practically the entire basin upfjord of the sill and below a depth of 95 m is at a concentration equal to or higher than 10 percent of the bottom concentration. Following the peak of the deep water renewal period, contours of tailings concentrations withdraw from the outer sill area.

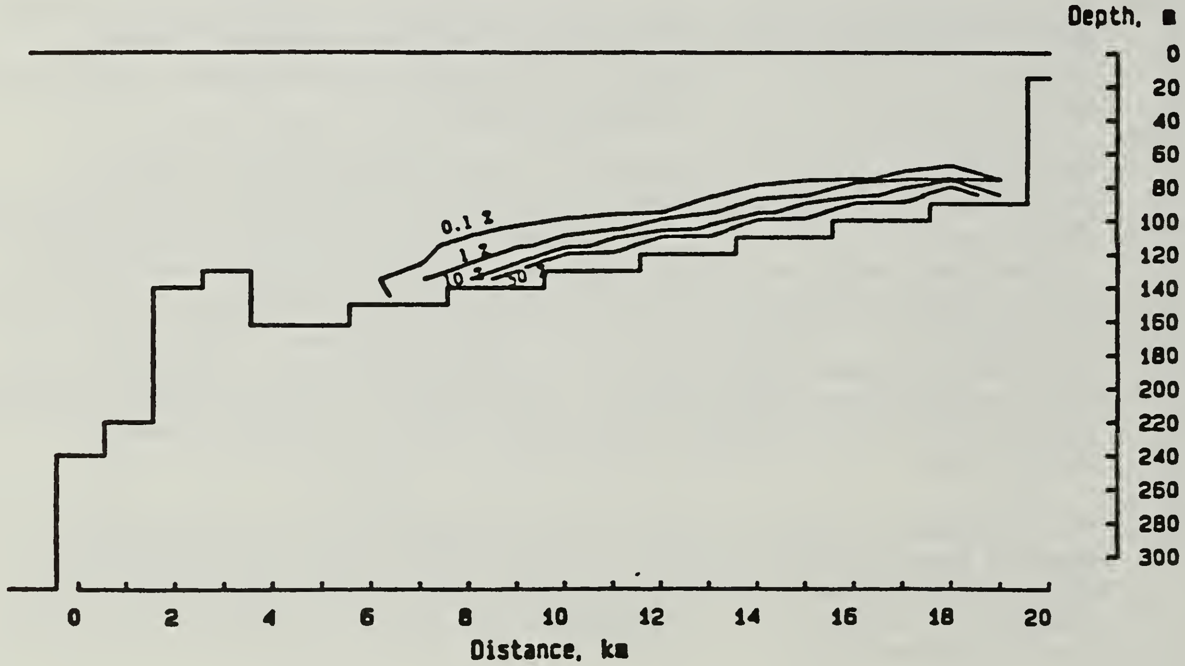
The transport rate slows down after the peak of the deep water renewal period when the circulation of the entire fjord weakens. Small quantities of fines (1 percent of the bottom concentration) continue to be transported out over the Smeaton Bay sill.

The numerical circulation model was also used to predict the distribution of tailings fines within Wilson Arm/Smeaton Bay during the final year of operation of the proposed outfall. Modified bathymetry of the fjord was simulated by the Bechtel sedimentation model. The distribution of suspended fines as predicted by the model is presented in Figure 4-14. As predicted by the model, tailings fines were transported toward the outer sill. Subsequently, circulation in the fjord weakened and the tailings plume receded. Because the circulation within the fjord is weaker, the extent of the tailings plume is diminished.

As indicated in Figure 4-13, some tailings would be transported out of Smeaton Bay as suspended fines and into Behm Canal. The amount of tailings that would leave Smeaton Bay cannot be precisely calculated. However, by making a few assumptions the amount of tailings involved can be approximated:

- Smeaton Bay outflow occurs in a uniform layer between 60 and 120 m deep, above the outer sill (Nebert 1985).
- Average flows for this layer are 10 cm/sec during deep water renewal (May through September) and 5 cm/sec during nondeep water renewal periods) (Nebert 1985).
- Tailings concentrations above the sill are 4.0 mg/l (10 percent of bottom concentration) during deep water renewal and 0.4 mg/l (1 percent of the bottom concentration) during the rest of the year (based on circulation modeling results, Kowalik and Findikakis 1985, p. 67).

Therefore, the amount of tailings leaving Smeaton Bay is on the order of 300,000 tons/yr. This represents about 1 percent of the tailings annually discharged into Smeaton Bay during the early part of the 80,000 tpd phase of the project. The annual amount would decrease as



SOURCE OF TAILINGS IS ALONG FJORD BOTTOM STARTING AT THE HEAD OF WILSON ARM. CONTOURS ARE EXPRESSED AS PERCENT OF BOTTOM CONCENTRATION. DAY 80 OF SIMULATION.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-14
DISTRIBUTION OF TAILINGS FINES AS PREDICTED BY THE TIDE AND DENSITY DRIVEN CIRCULATION MODEL — DISCHARGE TO WILSON ARM, PROJECT YEAR 55.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE KOWALIK AND FINDIKAKIS DATE MAY 85	

Smeaton Bay is filled and would eventually approach zero because the currents within the basin would weaken and the flushing rate would decrease as Smeaton Bay is filled with tailings. Concentrations of tailings fines in Behm Canal would be very small, probably less than background concentrations.

Temporary shutdown of tailings production would result in the cessation of source material for turbidity currents. Tailings fines would slowly settle to the bottom. Episodic slumping of unstable deposited tailings would continue for quite some time.

Modification to the original bathymetry of the fjord and the associated changes to circulation and water column density structure resulting from tailings disposal would remain after the project is decommissioned. After tailings disposal is terminated, turbidity levels would return to background levels and the natural sedimentation rate of about 1 cm/year would resume.

With the exception of random event-type disturbances, tailings fines would remain below the pycnocline and would not impact the surface waters of Wilson Arm/Smeaton Bay. The presence of the pycnocline should help to prevent vertical movement of fines into the euphotic zone. Surface water impacts would be limited to short-term events with limited areal extent. The mechanisms that could move tailings into the near-surface waters are outlined below:

- Stratification is weakest throughout the fjord during late winter and early spring. This would be the most likely time for tailings to be brought into the surface waters by vertical motions associated with internal tides or commencement of deep water renewal.

- Strong currents on the inside slope of the outer Smeaton Bay sill are associated with deep water renewal. These currents could scour tailings deposited in the very deep portions of the basin. High speed current events occur in this region only during the late summer. The possibility that scoured tailings material could reach the near-surface waters is remote because of the small amount of tailings material involved, the infrequent nature of the event, the great depths involved, and the presence of strong stratification in the upper waters. Also, as the basin is filled the occurrence of strong downslope currents will diminish until the slopes that contributed to the currents are no longer present.

- Turbidity currents flowing counter to ambient currents could become unsteady if critical shear velocities are exceeded. The turbulence associated with unsteady currents could carry tailings upward. Calculations for Boca de Quadra have indicated that the flows will not exceed critical shear velocities. Similar flows in Smeaton Bay will also not exceed critical shear velocities.

- o Episodic slumping events having sufficient momentum could travel up adverse slopes. Turbulence associated with these events, plus upward movement through weakly stratified water, could transport large amounts of tailings upward. With the mode of discharge proposed for Wilson Arm/Smeaton Bay all tailings movement would be downfjord. Any upward movement of tailings related to episodic slumping events would be in the deepest portions of the fjord.

Temporary shutdown of tailings production would result in the cessation of source material for turbidity currents. Tailings fines would slowly settle to the bottom. A vertical decent of 330 ft (100 m) for the 10 micron size particles could require about 18 days (Bechtel 1984d). Episodic slumping of unstable deposited tailings would continue for quite some time.

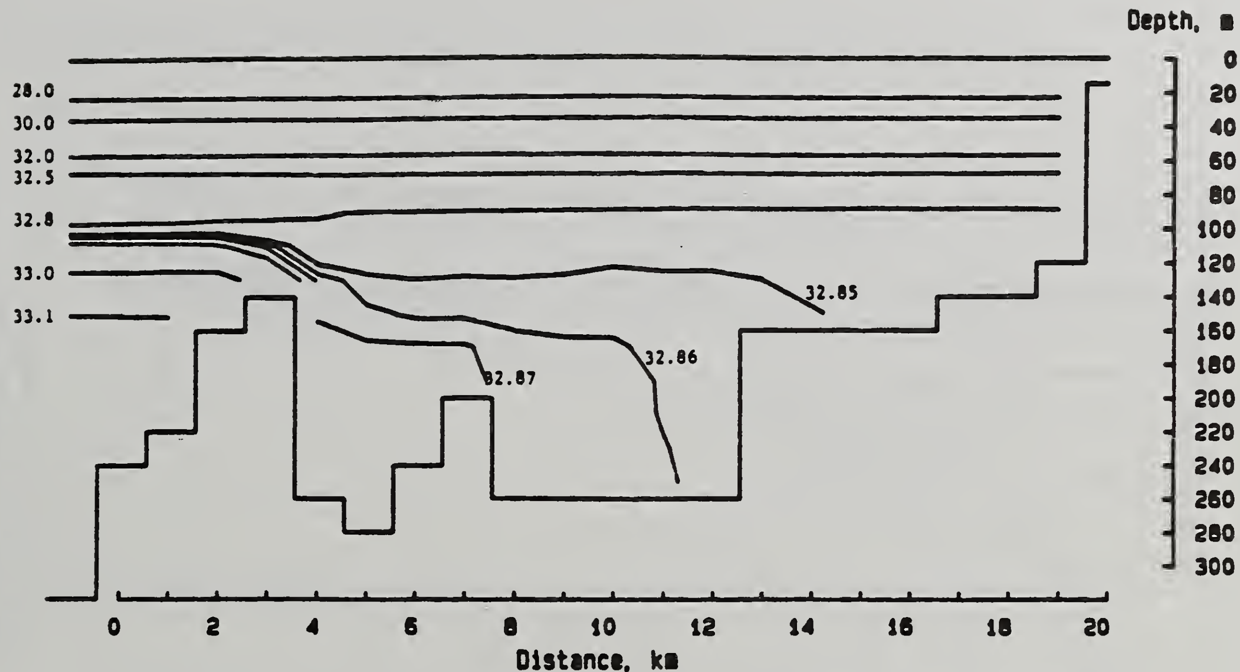
Hydrography and Circulation

Impacts to hydrography and circulation within Wilson Arm/Smeaton Bay have been predicted by the tide and density driven circulation model. The modeled features are for the deep water renewal period only. Major circulation features of the fjord, net sill depth outflows, net near surface inflows, and tidal currents are not anticipated to change.

Mean predicted salinities throughout the Smeaton Bay fjord are presented in Figure 4-15 for premine (a) and postmine (b) bathymetry. As indicated, salinities in the above sill waters remain basically unchanged, with the isohalines being nearly horizontal. Currents predicted by the circulation model are presented for premine (Figure 3-13) and postmine (Figure 4-16) bathymetry. As the Smeaton Bay basin fills, deep water renewal would become less effective as a circulatory driving force. The flushing rate of the fjord would decrease as the circulation patterns weaken. Currents above the filled basin are greatly weakened while near-surface currents are actually stronger. Postmining currents in Wilson Arm/Smeaton Bay resemble a typical estuarine circulation pattern. Impacts to the hydrography and circulation of Smeaton Bay resulting from tailings disposal are considered significant.

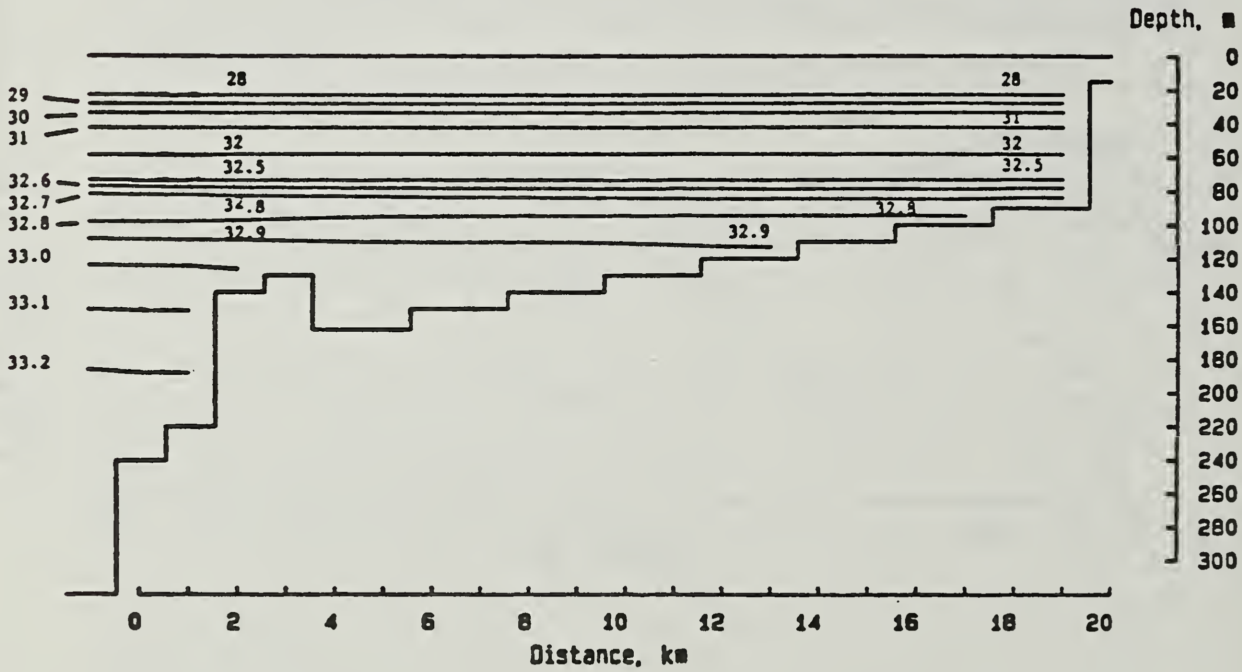
Freshwater requirements of mill operation and freshwater plumes associated with tailings pipeline operation and maintenance would modify the hydrography of the fjord. These hydrographic impacts would be similar to the impacts described in Section 4.1.6.2.

Because the tailings would be transported by pipeline for a short distance (400 ft) along the side of the fjord, the possibility of a pipeline rupture must be considered. A pipeline rupture could release up to 11,240 cu yd (8,600 cu m) of tailings to the surface waters of the fjord. Environmental risks and impacts associated with pipeline ruptures and containment system failures of the proposed project are



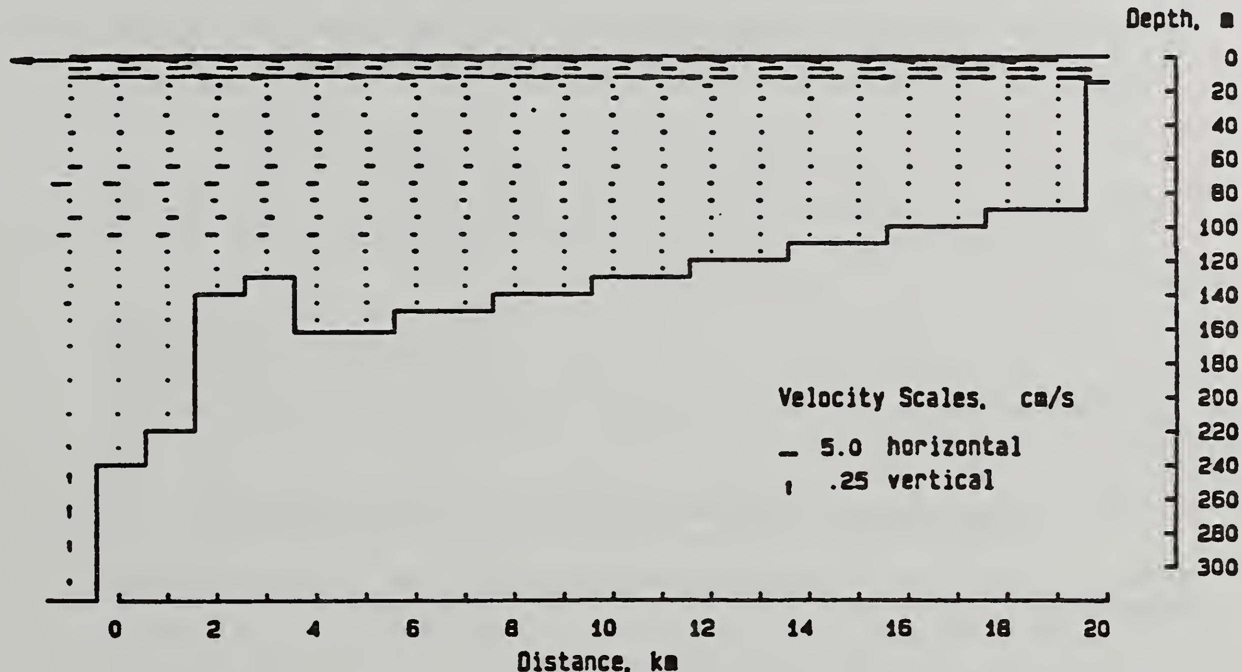
SALINITIES ARE IN PARTS PER THOUSAND. DAY 80 OF SIMULATION, DEEP WATER RENEWAL PERIOD.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-15a
SMEATON BAY SALINITY DISTRIBUTION PREDICTED BY TIDE AND DENSITY CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD.	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE FINDIKAKIS (1985) DATE MAR 1985	



SALINITIES ARE IN PARTS PER THOUSAND. DAY 80 OF SIMULATION, DEEP WATER RENEWAL PERIOD.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-15b
SMEATON BAY SALINITY DISTRIBUTION PREDICTED BY TIDE AND DENSITY DRIVEN CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD PROJECT YEAR 55	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE KOWALIK AND FINDIKALIS DATE MAY 85	



DAY 80 OF SIMULATION.

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE 4-16
POST PROJECT SMEATON BAY CURRENTS COMPUTED BY THE TIDE AND DENSITY CIRCULATION MODEL — DEEP WATER RENEWAL PERIOD	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE KOWALIK AND FINDIKALIS DATE MAY 85	

discussed briefly in Section 4.2.1.4, and in greater detail in Appendix G, Sections B and C. The risk of impacts on aquatic populations from mill tailings pipeline usage is considered insignificant.

4.1.6.6 Beaver Creek Mill with Boca de Quadra Tailings Disposal

The impacts from this alternative would be the same as those discussed in Section 4.1.6.2.

4.1.6.7 Beaver Creek Mill with Wilson Arm Tailings Disposal

The impacts from this alternative would be the same as discussed for the Tunnel Creek mill with Wilson Arm tailings disposal.

4.1.6.8 Beaver Creek Mill with On-Land Tailings Disposal

There would be no impact on physical oceanography resulting from on-land tailings disposal. There would be insignificant impact from operation of the Wilson Arm wharf.

4.1.6.9 North Meadow Mill with Boca de Quadra Tailings Disposal

Impacts from this alternative would be the same as described in Section 4.1.6.2.

4.1.6.10 North Meadow Mill with On-Land Tailings Disposal

Impacts from this alternative would be the same as described in Section 4.1.6.8.

4.1.7 Chemical Oceanography

4.1.7.1 No Action

If no action is taken, there would be no impact on the chemical oceanography of the fjords.

4.1.7.2 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Inner Basin and Commute Option

Impacts on the water quality of the fjords during the construction phase of the project would include increased turbidity and suspended sediment concentrations due to construction-related erosion. Increases in total suspended sediment load of the local rivers have been quantified in Section 4.1.5, Water Quality. The effects of construction activities within the fjords would be localized in nature and of several months duration. The ratio of the freshwater discharge volume to the tidal prism is low for both Boca de Quadra and Smeaton Bay and the river-driven surface flow is weak. Therefore, any project-related turbidity plumes would be expected to be confined to the heads of inlets and in the immediate area of wharf construction. In addition, the fjords are periodically exposed to high concentrations of suspended sediments from natural events such as floods, landslides, and submarine slumping. The overall impact of construction on marine

water quality is, therefore, expected to be insignificant. Fill material utilized during construction of the Wilson Arm wharf and the tailings disposal outfall in Boca de Quadra would consist of material excavated from the project area. This material should not be a contaminant carrier and therefore would not impact the water quality of either fjord.

The discharges of sewage from floating construction camps would be small, approximately 14 gpm from the Wilson Arm camp and 3 gpm from the Boca de Quadra camp. These discharges would comply with NPDES limitations and therefore would be expected to have insignificant impacts. The increased nutrient loading would be insignificant and immediate outfall-related impacts should be minimized with proper diffuser design.

During the operational phase of the project, the marine water quality of the fjords would be impacted by three types of discharges: (1) discharge of sewage effluent and wharf area drainage from the Wilson Arm wharf into Wilson Arm; (2) mine and facility area drainage and minor wastewater flows that would be discharged from ponds into Hill Creek, which enters Boca de Quadra through the Keta River, and Beaver Creek, which enters Wilson Arm through the Blossom and Wilson rivers; and (3) mill tailings containing solids, dissolved metals, and milling reagents that would be discharged at a 150 ft (50 m) depth into the inner basin of Boca de Quadra. After the inner basin is filled to sill depth, tailings would flow via density currents or extended tailings pipelines into the central basin of Boca de Quadra.

The discharge from the Wilson Arm wharf would be small, approximately 43 gpm, would comply with NPDES limitations, and would have an insignificant impact. Increased nutrient loading would be minimal and proper diffuser design should minimize impacts in the outfall area.

Discharges from sediment impoundments to the freshwater creeks would be treated to meet receiving water standards. Resulting creek and river concentrations are quantified in Section 4.1.5, Water Quality. Concentrations of metals in the Keta and Blossom rivers would be within the range of natural concentrations. Therefore, impacts to the water quality of fjords would be insignificant.

Tailings Discharge

The tailings slurry from the mill consists of both dissolved and solid phase constituents. The slurry would be mixed with seawater prior to discharge in the fjord. The mixing with seawater would reduce the specific gravity of the tailings slurry to nearer that of seawater to minimize turbulence that might interfere with the settling of the tailings. The mixing ratio is expected to vary from 1 part tailings to 1 to 4 parts seawater by weight. The 1:1 mixing ratio would result in the highest discharge concentrations; therefore, a 1:1 mixing ratio is assumed throughout these analyses. It should be noted that a 1:1 slurry mixing ratio by weight is equal to approximately a 2:1 (seawater

to effluent) dilution of the liquid part of the slurry carrying the dissolved constituents, as the tailings slurry would leave the thickener at the mill at 40 to 50 percent solids by weight.

Potential impacts from trace metal constituents and milling reagents in the discharge have been evaluated. The analyses performed are detailed in Appendix F. Worst case dissolved constituent concentrations have been quantified for a horizontal distance of 100 m from the outfall and a vertical distance of 50 m from the outfall before inner basin filling and a vertical distance of 25 m after the inner basin is filled, and for the below-sill volume of the inner basin prior to filling. Concentrations in the central basin are discussed qualitatively as the far-field dilution of constituents cannot be quantified at this time. The results of tailings leaching experiments performed by EVS (1984a) were used to assess the behavior of the Quartz Hill mine tailings in the fjord environment and to determine the dissolved trace element concentrations in the tailings discharge. The leaching experiments conducted by EVS (1984a) are described in Appendix F.

The expected plume behavior and near-field discharge dilution have been determined from initial physical plume modeling. These studies are discussed in Appendix F. The dilutions provided by Bechtel (1984b) for a horizontal distance of 100 m from the outfall and vertical distances of 50 m and 25 m have been used to predict constituent concentrations in the near-field discharge plume. The 50 m vertical distance has been selected because the discharge plume would flow below sill depth in the inner basin at this vertical distance. After entering the inner basin, further dilution of dissolved constituents may be restricted (see discussion in Appendix F). By the time the inner basin has been filled, tailings would have been deposited to a depth of approximately 75 m in the vicinity of the outfall. This build-up would reduce the vertical distance traveled by the plume. Therefore, dilution of the near-field discharge plume at the seabed would be reduced. Dilutions estimated for a horizontal distance of 100 m from the outfall would continue to be achieved. The dilutions used to calculate concentrations in the near-field plume are shown in Table 4-7.

The tailings temperature ranges from 8.9°C to 10.6°C (48°F to 51°F) in winter and from 12.8°C to 15.6°C (55°F to 60°F) in summer. The seawater intake for the mixing chamber is located at a depth of 36 m (120 ft) below the surface and the outfall port at a depth of 46 m (150 ft). At these depths, fjord water temperatures are 7°C to 8°C (44.6°F to 46.4°F) year round. Assuming conservative mixing of the discharge with ambient waters, temperature variation in the below-sill volume would not exceed a 1°C to 2°C increase during the summer months.

Dissolved Trace Element Concentrations - The dissolved concentrations calculated using the dilutions shown in Table 4-7 are presented in Columns 4 and 5 of Table 4-8. As shown by comparing columns 4 and 5 to columns 8 through 10 in Table 4-8, all dissolved constituent concentrations in the near-field discharge plume would be below both the EPA criteria and the Alaska drinking water standards at a horizontal distance of 100 m from the outfall and a vertical distance of 50 m from the outfall for all metals except mercury. For a reduced

TABLE 4-7

NEAR-FIELD DISCHARGE PLUME DILUTIONS FOR OUTFALL ON A 25 DEGREE SLOPE 1/

	Dissolved Constituents		Suspended Solids	
	Above Sill and Worst Case Below Sill Inner Basin Prior to Basin Filling	Worst Case After Inner Basin is Filled 2/	Above Sill and Worst Case Below Sill Inner Basin Prior to Basin Filling	Worst Case After Inner Basin is Filled 2/
Dilution	14:1	5:1	8:1	3.5:1
Horizontal Distance from Outfall (m)	100	50	100	50
Vertical Distance from Outfall (m)	50	25	50	25

1/ Early modeling results (Bechtel 1984b) indicated that the lowest initial dilutions anticipated would range between 5 and 14. Later modeling results (Jain and Kennedy 1984) reported minimum dilutions of 10:1; however, the possible effects of tailings build up around the outfall were not discussed. Given the inherent uncertainties associated with the modeling analyses and the minor differences between dilutions reported in the two studies, the evaluations performed using dilutions of 5 and 14 were maintained and are considered to be appropriate representations of dilutions that may be achieved at the outfall.

2/ Dilutions are presented as parts seawater to 1 part tailings discharge. These are the dilutions achieved at the outfall and do not include premixing. Due to build-up of deposited sediments in the vicinity of the outfall, the vertical distance traveled by the near-field discharge plume would be reduced from 50 m to 25 m after the inner basin is filled. The reduced dilutions shown would occur at a horizontal distance of 50 m from the outfall; however, dilutions reported for a horizontal distance of 100 m from the outfall would continue to be achieved.

TABLE 4-8

NEAR-FIELD DISSOLVED METAL CONCENTRATIONS
FOR THE PROPOSED DISCHARGE TO THE INNER BASIN
(all concentrations µg/l except as noted)

	Near Field Dissolved Concentrations				Total Recoverable 2/ Concentrations		EPA Criteria			
Metal (1)	Baseline (2)	Discharge 1/ (3)	Above Sill 100 m From Outfall and Worst Case Below Sill Inner Basin (4)	Worst Case After Inner Basin is Filled (5)	Above Sill 100 m From Outfall and Worst Case Below Sill Inner Basin (6)	Worst Case After Inner Basin is Filled (7)	Total 3/ Recoverable (8)	Total 4/ Recoverable (9)	Alaska 5/ Drinking Water Standards (10)	Criteria Exceeded (11)
Ag	0.002	2.33	0.15	0.39	1.47	3.03		2.3	50	After basin filled
As	1.40	3.20	1.52	1.70	116.02	227.18	36 6/		50	Yes
Cd	0.08	5.05	0.41	0.91	13.9	27.8	9.3		10	Yes
Cr	0.15	11.43	0.90	2.03	102.85	205.88	50 7/		50	Yes
Cu	0.30	11.87	1.07	2.23	509.7	1,019.3	2.9 8/		1,000	Yes
Fe	1.0	0.20	0.95	0.87					300	No
Hg	0.001	0.40	0.028	0.068	0.51	1.02	0.025		2	Yes
Mn	2.0	550	38.53	93.33	2,494.55	5,004.31		100 9/	50	Yes
Mo	9.0	500	41.73	90.83						No criteria
Ni	0.4	96.93	6.84	16.49	187.57	369.17		7.1		Yes
Pb	0.01	40.01	2.68	6.68	231.7	463.3	5.6		50	Yes
Se	0.10	2.27	0.24	0.46	1.26	2.50		54 10/	10	No
Zn	0.50	26.00	2.20	4.75	535.11	1,070.34		58	5,000	Yes

1/ Concentration of the 1:1 by weight (seawater:slurry) or 2:1 by volume (seawater:water effluent only) discharge. See Appendix F, Table F-2.

2/ Calculated by multiplying suspended solids concentration (g/l) by the extractable metal content of tailings solids (µg/g) and adding the dissolved concentration to this product. These numbers are representative of metals associated with both the solid and dissolved phases. As shown by comparing columns 4 and 5 with 6 and 7, the majority of the total recoverable metal concentrations are due to metals associated with suspended soilds.

3/ Four-day average concentration not to be exceeded more than once every three years (EPA 1985). Total recoverable concentration which is operationally defined as the concentration of metal in an unfiltered sample following treatment with hot dilute mineral acid (EPA 1979b).

4/ EPA criteria for 24-hour average or concentration not to be exceeded at any time (EPA 1980h, l, m, n). Total recoverable concentration which is operationally defined as the concentration of metal in an unfiltered sample following treatment with hot dilute mineral acid (EPA 1979b).

5/ Alaska DEC specifies that either EPA criteria or Alaska Drinking Water Standards, whichever is less, shall apply.

6/ Trivalent arsenic; forms of arsenic in the discharge unknown.

7/ Hexavalent chromium; forms of chromium in the discharge are unknown.

8/ One-hour average concentration not to be exceeded more than once every three years on the average (EPA 1985).

9/ EPA 1976.

10/ Total recoverable inorganic selenite; form of selenium in discharge is unknown.

vertical distance (25 m after inner basin filling), dissolved Ni concentrations exceed the EPA criteria. All other dissolved concentrations, except Hg, would be below the criteria and drinking water standards at this distance. The dissolved concentrations shown in Table 4-8 are considered to be conservative estimates of concentrations in the near-field zone and below-sill volume because removal from the dissolved phase has not been quantified. The dissolved phase is of primary concern with respect to bioavailability. Therefore, in the worst case analysis it is assumed that the metals remain in the dissolved state. It should be noted that many of the dissolved metal ions would be subject to natural removal mechanisms such as adsorption onto suspended particulates or formation of solids by precipitation reactions. Removal processes may result in lower dissolved concentrations than those predicted by dilution calculations.

The EPA criteria for metals are specified in terms of total recoverable metal concentration which includes both dissolved and solid phase metal content. As shown by comparison of columns 6 and 7 with columns 8 and 9 in Table 4-8, total concentrations of As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, and Zn would exceed the EPA total recoverable criteria at a horizontal distance of 100 m and vertical distances of 50 m and 25 m from the outfall. After the inner basin has been filled, Ag would also exceed the EPA criteria at a vertical distance of 25 m from the outfall.

Based on the suspended solids concentrations estimated from data measured at the Island Copper outfall and the estimated extractable metal content in the tailings solids, it appears that water column trace element concentrations would be below the criteria at a distance of 300 m from the outfall. Estimated suspended solids concentrations are presented in Appendix F, Table F-5. These concentrations are compared to the suspended solids concentrations above which the EPA criteria would be exceeded in Appendix F, Table F-7. Within the turbidity plume (a layer approximately 12 m above the bottom), Cu, Hg, Mn, Ni, and Pb concentrations may remain above the criteria 300 m from the outfall. In the below-sill volume of the inner basin where continued dilution of dissolved constituents would be restricted, Cu, Hg, Mn, Ni, and Pb concentrations in the turbidity plume may remain above the criteria at a distance of 1,000 m from the outfall. At this distance, highest suspended solids concentrations would occur in a layer approximately 6 m above the bottom. Following basin filling, the plume would not be entering the below-sill volume and the supply of dilution water would not be limited. Therefore, dilution of dissolved constituents would not be restricted, and most concentrations within the turbidity plume would probably be below the criteria at a distance of 1,000 m from the outfall. Copper may remain above the criteria in the turbidity plume at 1,000 m, but would probably be below the criteria at a distance of 12 m above the bottom.

Impacts on fjord water quality arising from trace elements in the discharge should be relatively minor. Those metals for which criteria are specified as total recoverable would exceed the EPA criteria within the near-field discharge plume. The best available data indicate that by a distance of 300 m from the outfall any concentrations above the criteria would be restricted to within the turbidity plume, a layer

approximately 12 m above the bottom. After the inner basin has been filled, plume concentrations should be below the criteria by a distance of 1,000 m from the outfall with the possible exception of copper. Copper concentrations in excess of the criteria would be restricted to that portion of the plume with the highest suspended solids concentration.

Tailings Leaching - Following discharge and near-field dilution, trace metals may continue to be released from the tailings solids. The leaching experiments performed by EVS (1984a) were used to assess the potential for continued release and are discussed in Appendix F. Many metals exhibit either no release or rapid release. For these metals, dissolved concentrations should not exceed the concentrations shown in Table 4-8 for the near-field discharge plume.

Release of dissolved constituents appears to be a function of total tailings solids concentration (Hoff et al. 1982, p. 286). This indicates that only a fixed amount of those elements exhibiting release are readily leached from the tailings solids and that continual leaching of discharged solids is not expected. This observation is supported by the EVS (1984a) bioassay results and conclusions, which indicated that toxicity to test organisms decreased as the concentration of tailings decreased and that tailings-related mortalities are due to chemical effects rather than physical processes such as clogging of respiratory membranes (EVS 1984a, p. 28).

EVS 1984b (p. 30) reports that leaching analyses of tailings effluent indicate release of Mn and Mo in excess of amounts leached from control sediments. With time (one month for Mo and two months for Mn), concentrations declined to within the range of control values.

Analysis of ambient water column concentrations outside of the near-field discharge zone and tailings turbidity plume becomes complex for metals that exhibit leaching. Resultant water column concentrations cannot be assessed without consideration of removal processes that may be occurring. Adsorption has been recognized as an important mechanism for controlling the concentration of trace constituents and their transport through natural water bodies (Benjamin and Lecki 1980, page 305). The process of "sorption" consists of several mechanisms including physical adsorption on the external surface of a particle, chemical adsorption characterized by the formation of chemical associations, ion exchange, and incorporation into mineral lattices. In practice, sorption processes are highly complicated interactions of various mechanisms and substrates (Forstner and Salomons 1981, p. 249). Direct precipitation reactions also participate in the redistribution of trace elements between the dissolved and solid phases.

At present, the best available means of assessing potential water quality impacts arising from tailings leaching is the change observed in water quality at similar mining operations (see discussion in Appendix F). The experiences in Alice Arm and Rupert Inlet suggest that tailings leaching would not result in degradation of water quality. However, the flushing regime and volume of tailings to be discharged are different in Boca de Quadra than in Alice Arm or Rupert

Inlet. Data that would enable leaching and removal rates to be quantified are not available; therefore, potential increases in dissolved ambient concentrations cannot be estimated.

Tailings Solids - In addition to dissolved ambient trace element concentrations, the changes in sediment characteristics arising from deposition of tailings solids is of concern. In Alice Arm, B.C., mine tailings deposits are enriched in those elements that have higher concentrations in the tailings solids than in natural sediments. Similarly, concentrations in tailings deposits are reduced for those elements that are lower in concentration relative to natural sediments (Goyette and Christie 1982a, p. 22). On this basis only Mo would be elevated in the deposited tailings relative to natural background sediments (see Appendix F, Table F-6).

The tailings deposits would be lower in organic content than naturally deposited sediments. Concentrations of dissolved trace elements in interstitial waters are known to vary with organic content. To assess potential impacts arising from the decreased organic content, proposed sediment criteria, which are presently being evaluated by EPA, are utilized (Pavlou and Weston 1984). The criteria are based upon the assumption that, at equilibrium, the trace metals will be distributed between the dissolved and solid phases (i.e., dissolved in interstitial water or adsorbed to sediments). These criteria are normalized to account for the effect of sediment organic content on metal partitioning and are designed to prevent dissolved concentrations in interstitial waters from exceeding EPA water quality criteria. The tailings solids trace metal content is compared to the proposed sediment criteria in Table 4-9.

The sediment criteria are presented with a specified degree of uncertainty. It is suggested by Pavlou and Weston (1984) that the mean criteria value be regarded as an alert level, while the maximum value be considered the maximum permissible metal content. On this basis, none of the metals for which proposed criteria have been developed would exceed the maximum permissible metal content. Concentrations of As, Cu, and Pb may be considered in the alert level.

As long as waters overlying the sediments remain oxygenated, long-term release of metals into overlying waters would not be expected. Further discussion of long-term releases is presented in Appendix F.

Deposition of the low organic content tailings solids would result in decreased release of nutrients from the sediments (Burrell 1983, Chapter 5, p. 26). However, the flux of nutrients from the sediments is less than 20 percent of the annual requirements of the overlying euphotic zone. The reduced flux resulting from tailings deposition is unlikely to substantially impact primary production in the near-surface waters (Burrell 1983, Chapter 5, p. 26).

Milling Reagents - A number of milling reagents that may be utilized during the ore processing are listed in Table 4-10. During the pilot plant operations, several reagents were tested to find suitable alternatives (U.S. Borax 1984b, Table 6). Through the normal operating

TABLE 4-9

COMPARISON OF METAL CONTENT IN TAILINGS SOLIDS
WITH PROPOSED SEDIMENT CRITERIA

Metal	Metal Content in Tailings Solids (ug/l) 1/	Sediment Criteria 2/ for Chronic Exposure (ug/g)		Criteria Exceeded
		Mean 3/	Maximum 3/	
As	10.9	8.2	16.1	Alert level 4/
Cd	2.4	7.7	17.7	No
Cu	69.0	34.0	76.0	Alert level 4/
Pb	47.0	33.0	67.0	Alert level 4/
Hg	<0.05 (not detected)	0.008	0.019	No
Zn	46	190 5/	570 5/	No

1/ Total metal content from U.S. Borax (1984a).

2/ Recommended sediment criteria, corrected for organic content (Pavlou and Weston 1984). Tailings organic content assumed to be 1 percent.

3/ The sediment criteria are presented as a mean with a specified level of uncertainty. Mean concentration may be considered an alert level, while the maximum concentration may be considered the maximum permissible concentration.

4/ Alert level indicates that the tailings solids concentrations are greater than the mean criteria value and are within one standard deviation of the mean. Additional testing such as bioassays may be required to assess the significance and potential impacts of these concentrations.

5/ Zn criteria based upon total recoverable concentration.

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TABLE 4-10

MILLING REAGENT CONCENTRATIONS IN THE NEAR-FIELD DISCHARGE PLUME

Reagent 1/	Percent in Dissolved Phase of Effluent	Usage Lb/Short Ton Ore 1/	Concentration in Effluent (mg/l)	Biodegradability	Worst Case Before Inner Basin is Filled (mg/l) 2/	Worst Case After Inner Basin is Filled (mg/l) 3/
Dowfroth 25 or ALFOL 6	100	0.003	1.20	No 4/	0.027	0.067
	100	0.045	18.05	Readily 5/	0.40	1.003
MIBC	100	0.088	35.30	Readily 4/	0.784	1.960
Fuel Oil		0.634	0.01 6/	No	<0.001	0.001
Stepanfloat 85L	100	0.011	4.41	Expected degree unknown 7/	0.098	0.246
Sodium Silicate and/or CMC-7	100	0.063	25.27	No	0.562	1.404
	50 8/	0.045	9.02	With difficulty 4/	0.200	0.501
Nokes	5 9/	0.054	10.83	No	0.0243	0.061
M502 or SF330 10/	50 8/	0.199	39.91	Expected degree unknown 7/	0.887	2.218
	50 8/	0.010	2.00	Expected degree unknown 7/	0.045	0.112
Lime	100	0.134	53.74	No	1.195	2.986
Aerodri	50 8/	0.0002	0.04	Expected degree unknown 7/	0.001	0.002

1/ U.S. Borax (1984b) and Project Description.
2/ Diluted 2:1 in mixing box and 14:1 at a distance of 100 m from the outfall.
3/ Diluted 2:1 in mixing box and 5:1 at a distance of 50 m from the outfall.
4/ Read and Manser (1975, p. 246).
5/ U.S. Borax (1984c).
6/ U.S. Borax (1983a, p. 8-40).
7/ Most organic compounds are expected to undergo some biodegradation; however, specific testing of the biodegradability of this reagent was not available.
8/ Approximately half of the organic reagents would remain in the tailings discharge (U.S. Borax 1983, CATDA Appendix E, p. 16). For the worst case, reagents accompanying the tailings are assumed to remain dissolved.
9/ Assumes 95 percent converted to H_3PO_4 and H_2S. H_2S is the toxic component of concern; however, resultant H_2S is utilized to depress trace metals by formation of insoluble sulfites and will therefore not be discharged in significant quantities.
10/ These application rates may be much higher than will actually be required as other types of flocculants will be tested (Poling 1984).

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life of an actual concentrator, the reagent scheme and application rate may vary somewhat to optimize performance (Poling 1984). Final milling reagent usage cannot be well characterized at this time; therefore, it is appropriate to consider potential effects of all reagents. The concentration of milling reagents in the near-field discharge plume, prior to and after inner basin filling, are shown in Table 4-10. Criteria are only established for fuel oil; the criteria is equal to 0.01 mg/l and would not be exceeded. Available toxicity data are presented in Appendix G, Table 13-3. Comparison of predicted reagent concentrations in the mixing zone with available toxicity data indicates that reagent concentrations would be below known toxicity levels in the near-field discharge plume.

The primary concern regarding the discharge of milling reagents to the fjord is the potential impact on dissolved oxygen concentrations in the basin's below-sill depth. Several of the reagents are organic compounds that would consume oxygen during degradation. The degree to which oxygen may become depressed below natural levels depends primarily on the degree to which compounds degrade, the rate at which degradation occurs, the rate that oxygen is replenished in the basin, and the residence time of basin waters. None of these factors are well known.

Biological oxygen demand (BOD) laboratory results provided by U.S. Borax (1985c), indicate that the maximum BOD of the tailings effluent is 30 mg/l. This value was used in conjunction with the plume volume to compute the dissolved oxygen demand of the discharge. The computed BOD was compared to the oxygen contained in the plume to evaluate the potential for dissolved oxygen depressions in the fjord. The maximum BOD of the discharge was computed to be 28 percent of the dissolved oxygen entrained in the plume; these calculations are detailed in Appendix F, Table F-8. The discharge plume would contribute a net gain in dissolved oxygen to the below-sill volume. Depressions in dissolved oxygen concentrations are, therefore, not expected.

Cumulative impacts (additive effects from the various discharges) are not expected within either fjord because:

- Sewage effluent would meet NPDES criteria and mine drainage from water quality control facilities would be treated to meet receiving water standards. Mine drainage would be substantially diluted within the rivers prior to entering the fjord (see Section 4.1.5) and many of the riverborne dissolved metals may be expected to be removed from the dissolved phase in the freshwater/saltwater mixing zone.

- Sewage discharges and diluted mine drainage would enter the surface waters of the fjord, which remain relatively isolated from the deeper waters into which tailings would be discharged.

After the project is completed and mining-related discharges to the fjord cease, trace element concentrations and dissolved oxygen levels in the fjord should return to natural premine conditions within one to two years. This conclusion is based on the expected annual renewal of

deep basin waters. Additionally, long-term leaching of tailings solids is not expected, and oxygenated surficial sediments should inhibit any long-term release of metals from the sediments.

The time required for sediments to return to premine conditions would depend upon sedimentation rates and bioturbation (disturbance by benthic organisms) of the surficial sediment layer. Areas of the fjords with high natural sedimentation rates would return to premining conditions most rapidly. Thus, areas where sedimentation rates are on the order of 1 cm/year may return to natural conditions within five years. Areas subject to sedimentation rates on the order of 0.1 cm/year may require several decades to return to premine conditions.

Bioturbation may prolong the recovery process by mixing underlying tailings solids into natural deposits. Bioturbation homogenizes the uppermost sediment. After a time lapse of several years, the effect of bioturbation would be a decreasing pollutant gradient with increasing depth in the sediment. An unpolluted topmost layer of bottom sediment would result (Cato et al. 1980, p. 409).

In the event that tailings do not flow freely into the central basin, the outfall location would be moved 22,000 ft to the southwest. Discharge would then be directly into the central basin for the remainder of the project and deposition to the inner basin would cease. Impacts to the central basin would be the same as those described above except that dilution of near-field dissolved trace element concentrations would not be reduced as a result of tailings deposits build-up in the outfall vicinity. Dilutions predicted for a horizontal distance of 100 m and a vertical distance of 50 m from the outfall would be achieved.

4.1.7.3 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Central Basin and Commute Option

For discharge directly to the central basin throughout the project life impacts would be the same as those described in Section 4.1.7.2 except:

- Dilution of near-field dissolved trace element concentrations would not be reduced as a result of tailings deposits build-up in the outfall vicinity. Therefore, dilutions predicted for a horizontal distance of 100 m and vertical distance of 50 m from the outfall could be achieved throughout the project life.

4.1.7.4 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

This alternative would impact the chemical oceanography of Boca de Quadra exactly as described in Section 4.1.7.2.

4.1.7.5 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The concentrations of trace elements and reagents in the mixing zone at a dilution of 14:1 would be the same as those reported for Boca de Quadra in Table 4-9. As the Smeaton Bay basin fills with tailings,

dilutions would be reduced as tailings are deposited in the vicinity of the outfall. Worst case concentrations following basin filling would be the same as those shown in Table 4-8.

All other impacts would be the same as those described in Section 4.1.7.2.

4.1.7.6 Beaver Creek Mill with Boca de Quadra Tailings Disposal

Impacts would be identical to those described in Section 4.1.7.2.

4.1.7.7 Beaver Creek Mill with Wilson Arm Tailings Disposal

Impacts would be the same as described in Section 4.1.7.5.

4.1.7.8 Beaver Creek Mill with On-Land Tailings Disposal

There would be no impacts in the fjords from on-land tailings disposal. The other impacts would be the same as discussed in Section 4.1.7.2.

4.1.7.9 North Meadow Mill with Boca de Quadra Tailings Disposal

Impacts would be the same as described in Section 4.1.7.2.

4.1.7.10 North Meadow Mill with On-Land Tailings Disposal

Impacts would be the same as described in 4.1.7.8.

4.1.8 Noise

Human response to noise depends on many factors, including sound frequency, duration of noise occurrence, and the attitude of the listener regarding the noise source. For regulatory purposes, noise intensity is measured in decibels (dBA). Typical noise levels from common sources are listed below (EPA 1973a, p. 1.6):

Soft Whisper	30 dBA
Normal Conversation	70 dBA
Blaring Radio	110 dBA

The acceptability of a noise depends on the attitude of the listener. For example, a 70 dBA sound might be scarcely perceptible on a city street, while an unexpected 70 dBA sound in an otherwise quiet forest might be noticeable and therefore unacceptable.

To evaluate the noise impacts in the Misty Fiords National Monument Wilderness area, it was assumed that the intrusive noises must be attentuated to 15 dBA less than background levels before they become indistinguishable (Forest Service 1975, page 16). The measured background noise level at Wilson River was 42 dBA (Nugent 1983, Section 3.4), so at the wilderness boundary on the Wilson River the acceptable noise level from construction and mining activities would be 27 dBA. The background noise level at Bakewell Lake was 32 dBA (Nugent

1983, Section 3.4), so along Wilson Arm and at the Smeaton Bay wilderness boundary the acceptable noise level from construction and mining activities would be 17 dBA.

4.1.8.1 No Action

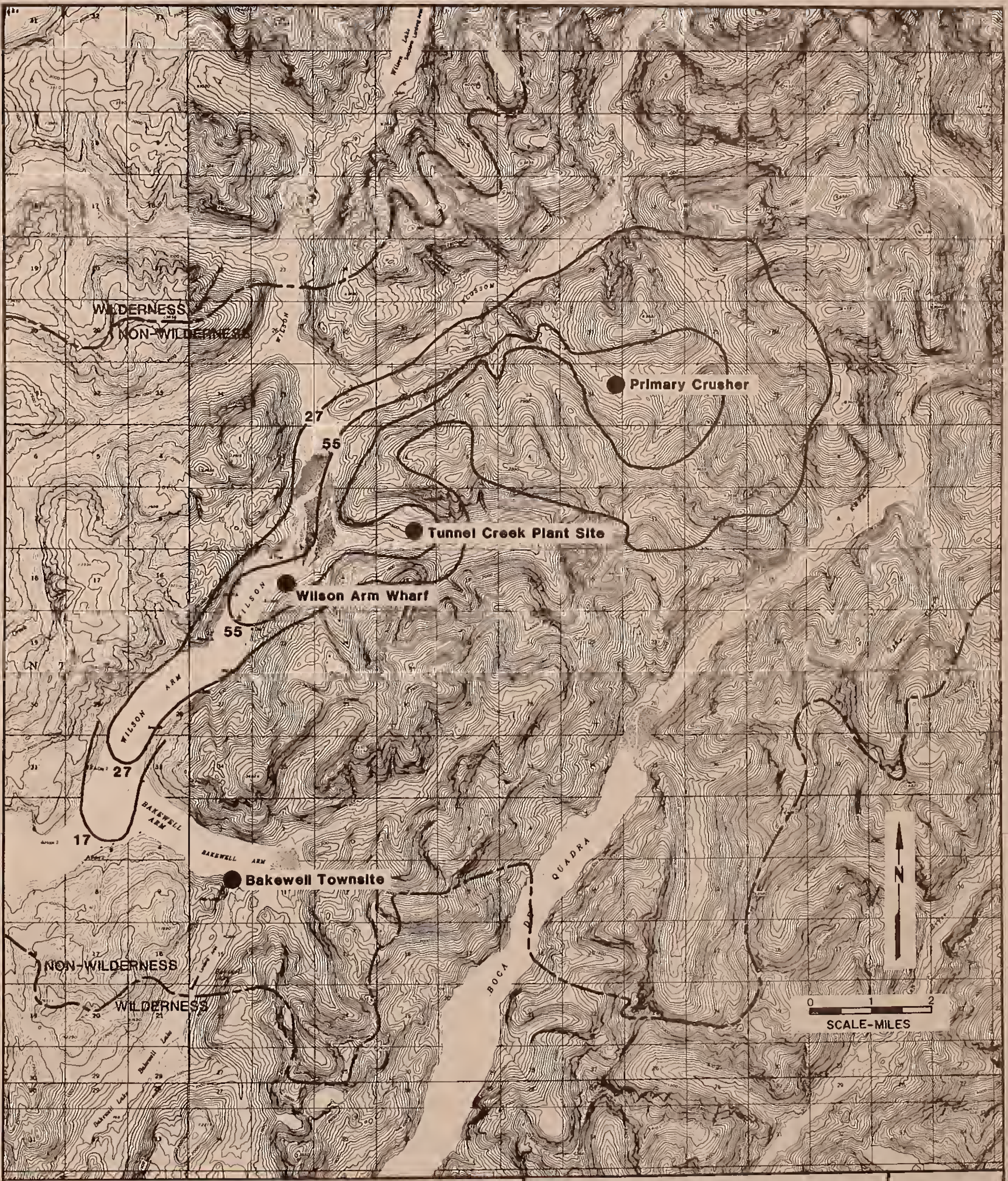
This alternative would result in noise levels remaining at their present low levels throughout the area.

4.1.8.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

The maximum noise levels were initially estimated using a computer model with the following assumptions (Nugent 1983, Part 3, Section 2): (1) continuous use of the mining equipment, processing equipment, and haul trucks; (2) roughly 10 to 20 dBA of foliage attenuation caused by dense trees within the first 300 ft of sound travel; (3) 15 dBA of additional near-source attenuation occurring within the next mile of sound travel; (4) long-range noise attenuation caused by hemispherical wave spreading, air absorption, wind, and thermal gradients; and (5) sound absorption and reflection off of the complex terrain modeled by establishment of 19 barriers with reflection/absorption properties similar to concrete structures.

The assumed 10-20 dBA foliage attenuation may be too high in some cases because the sound waves might not always have to pass through dense trees to reach the listener. However, this possible underestimation of noise levels is, in most cases, offset by the conservative assumption that sound reflection off the forested terrain is identical to reflection off of concrete structures. The most significant noise level underestimation probably occurred in the case where sounds originate at the Wilson Arm wharf and travel along an unobstructed path along Wilson Arm toward Smeaton Bay. The noise levels along Wilson Arm caused by construction and operation at the wharf were therefore reestimated using U.S. Forest Service calculation procedures that provide a more realistic estimate of noise levels along open water (Harrison et al. 1980, pp. 18-32). The following assumptions were used for the revised calculations: (1) no foliage attenuation because there would be no trees surrounding the wharf area; (2) long-range attenuation caused by hemispherical wave spreading and atmospheric absorption; and (3) unobstructured sound travel along Wilson Arm.

The construction phase activities (excluding blasting) should create insignificant noise impacts in the wilderness area. The estimated noise levels during the construction phase of the project are shown in Figure 4-17. The noise levels along Wilson Arm were calculated using the Forest Service calculation procedures (Harrison et al. 1980, pp. 18-32). The remaining noise levels are based on the earlier computer results (Nugent 1983, Part 3). The calculated 27 dBA contour, which is the level of no impact for the Wilson River wilderness boundary, would be located well inside the nonwilderness area near the Wilson River. The calculated 17 dBA contour, which is the level of no impact for the Smeaton Bay wilderness boundary, would also be located well inside the nonwilderness area.



LEGEND

—55—	Noise levels (L_{eq}) in dBA.
27 dBA	Forest Service designated level of no impact at Wilson River wilderness boundary.
17 dBA	Forest Service designated level of no impect et Smeeton Bay wilderness boundary.

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

CONSTRUCTION PHASE NOISE LEVELS

SOURCE: NUGENT (1983) DATE MAR 84

FIGURE 4-17

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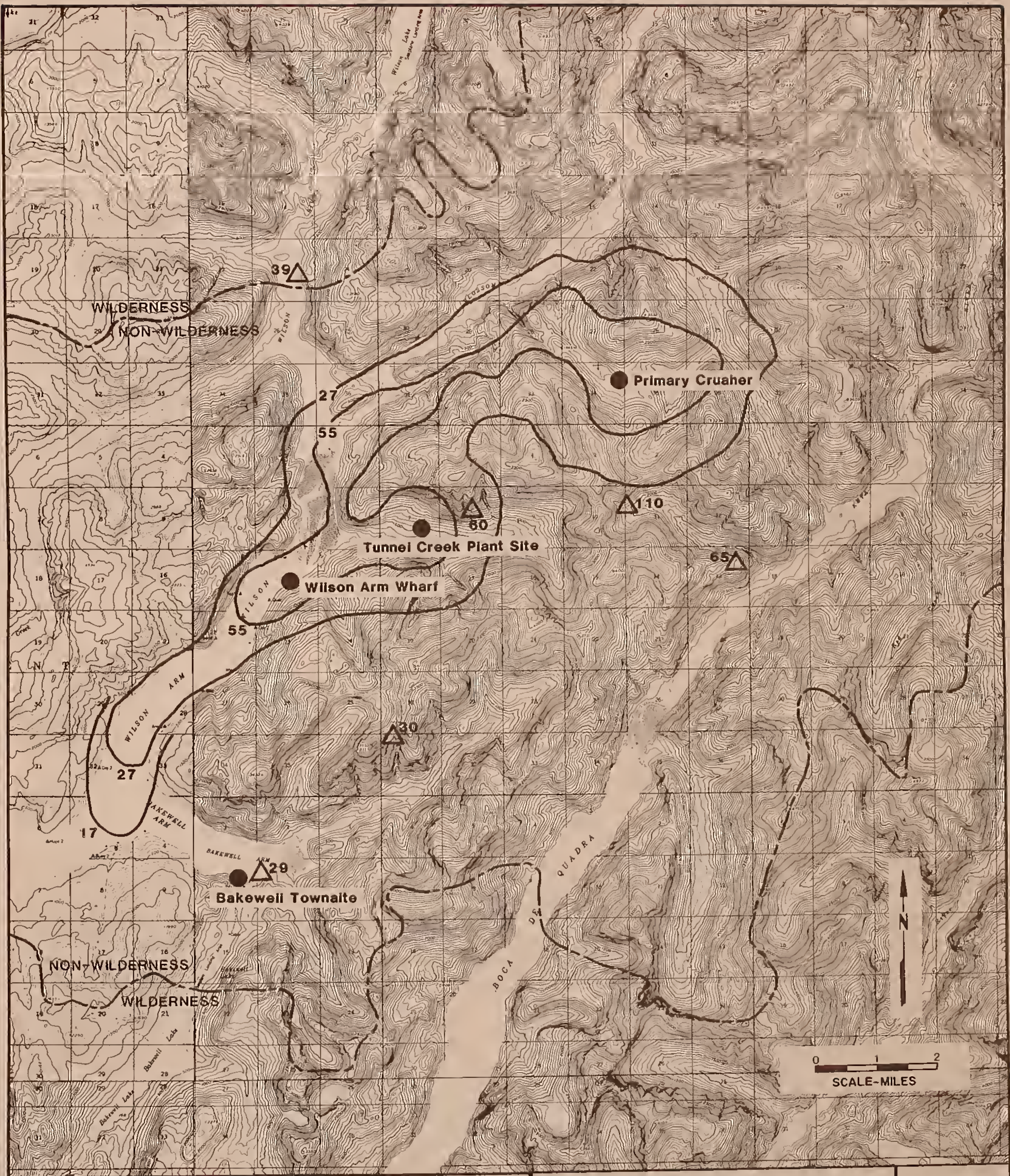
The mining phase activities (excluding blasting) would also create insignificant noise impacts in the wilderness area. The calculated noise levels for the mining phase of the project are shown in Figure 4-18. The noise levels along Wilson Arm were calculated using the Forest Service calculation procedures (Harrison et al. 1980, pp. 18-32). The remaining noise levels are based on the earlier computer results (Nugent 1983, Part 3). The calculated 27 dBA contour, which is the level of no impact for the Wilson River wilderness boundary, would be located well inside the nonwilderness area. The calculated 17 dBA contour, which is the level of no impact for the Smeaton Bay wilderness boundary, would also be located well inside the nonwilderness area.

The ships and ferries used to transport supplies, commuting workers, and ore concentrate would create moderately significant noise impacts along Wilson Arm. Passenger ferries would make five round trips per week between Ketchikan and Quartz Hill. Fuel tankers and transport barges would make one to two round trips per month. Based on the Forest Service calculation procedures (Harrison et al. 1980, pp. 18-32), passing ships would create short-term noise levels of roughly 86 dBA along the Smeaton Bay shoreline.

Blasting noises would create moderately significant impacts in the wilderness area. One or two blasts per day are planned, and would cause a very short-term noise similar to thunder. The estimated blast noise levels at the Wilson River wilderness boundary, Bakewell townsite, and at several identified goat habitats are shown in Figure 4-18. The maximum calculated blast noise level outside of the wilderness area boundary caused by mining blasting is roughly 39 dBA, which is quieter than normal conversation (EPA 1973a, p. 1-6). The blasting noise could possibly be distinguishable for up to 20 mi beyond the wilderness boundary in some locations.

The continuous mining noises and intermittent blasting noises could have moderately significant impacts on goat populations in the Quartz Hill region. These noises could force goats to abandon their normal habitats in favor of quieter but potentially less productive areas. The total carrying capacity of the region for goat populations could therefore be reduced. The noise impacts on goats are discussed in detail in Section 4.2.4, Wildlife. The blasting noises and blasting shock waves should create insignificant impacts in fish populations, as discussed in Section 4.2.2, Marine Ecology.

No specific numbers are available for the frequency of helicopter or seaplane flights to the site during construction or operation. However, there is no plan to use aircraft for regular commuting to Ketchikan and they are expected to be used only in emergencies or other urgent situations. Routine commuting and hauling would be by boat. When aircraft do fly to Ketchikan, the flight path would be at an elevation below 3,000 ft and along the shores of the waterways. The range that aircraft noise can be heard varies greatly, depending on the weather, terrain, altitude, and background sound level at the listener. Typically the range would be 2 to 4 mi for helicopter



LEGEND

—55—	Noise levels (L_{eq}) in dBA.	△ = Blast Noise
27 dBA	Forest Service designated level of no impact et Wilson River wilderness boundery.	
17 dBA	Forest Service designated level of no impact at Smeaton Bay wilderness boundary.	

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MINING PHASE NOISE LEVELS

SOURCE: NUGENT (1983) DATE MAR 84

FIGURE 4-18

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noise, but it is conceivable that, under the best conditions for sound transmission including the appropriate terrain configuration, the sound could be heard for 10 to 12 mi. Helicopter and seaplane noise are familiar and accepted noises to users of the area and their impacts are expected to be only moderately significant unless the expected number of flights is increased considerably.

It is possible that infrequent atmospheric conditions might arise that would transmit mining noises farther than indicated by the previous calculations. Construction noises have reportedly been distinguishable up to 12 mi away from the site near Big Goat Lake (Barber 1983a; Johnson et al. 1983). However, there is no record of the location or types of equipment that were operating on the days that the noises were reported, so it is not possible to estimate how often the conditions of long-range noise impacts might occur.

4.1.8.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

This alternative would create noise impacts similar to those described in Section 4.1.8.2. The loudest sounds from the Bakewell townsite would be caused by the diesel electric generators. However, the noises from the generators would be indistinguishable at the wilderness area boundary at Smeaton Bay. Continuous operations noises from Tunnel Creek and the mine site would be inaudible at the Bakewell townsite. Blasting at the mine would cause noise levels of only approximately 29 dBA at the Bakewell townsite (Nugent 1983, Appendix A).

4.1.8.4 On-Land Tailings Disposal Facilities

The project alternatives involving on-land tailings disposal would create noise impacts similar to those described in Section 4.1.8.2. These alternatives would require staged dam construction at both Tunnel Creek and Aronitz Creek. The noise impacts caused by the required Boca de Quadra haul road and pipeline construction, dam construction material hauling, and dam construction operations have not been modeled. However, it is likely that the noise sources from these activities would be similar to the corresponding noise sources described in Section 4.1.8.2. The noise propagation and attentuation characteristics at Aronitz Creek are probably similar to those at Tunnel Creek. Based on the low noise level calculated for the other project activities, the tailings disposal dam construction should cause insignificant noise impacts in the wilderness area.

4.1.8.5 Other Alternative Concepts

All other alternative concepts for location of the mining and processing facilities are so similar to the previously described project concepts in terms of noise sources that they would create noise impacts identical to those predicted in Section 4.1.8.2. The construction, mining, and postmining phase activities (exclusive of blasting) would create insignificant noise impacts. Ship traffic along Wilson Arm and mine blasting would create moderately significant noise impacts.

4.1.9 Hazards Susceptibility

4.1.9.1 No Action

In its present disturbed condition, the project area would continue to experience landsliding (as would undisturbed areas that are presently unstable by virtue of slope or soil conditions). The magnitude of the project-induced landslides is expected to be minor, and the number should decrease with time under this no action alternative. The impacts of landsliding would be largely restricted to the bulk sample access road. Lyons (1984) described 11 construction-induced landslides and rockslides during the Blossom River access road construction. Some of these buried vegetation and/or deposited material in Quartz Hill waterways.

Avalanche-related impacts would be insignificant. Although naturally occurring avalanches are common in the project area, few workers would be present, and exposure to avalanche hazards would be minimal.

4.1.9.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

Landslide hazards and impacts are expected to be most severe during the construction period. Significant landslide impacts would likely be restricted to the mine access road area. Excavation, filling, and blasting associated with widening of the access road may produce unstable slopes. The existing road will help control small rockslides and landslides during upslope widening. However, undercutting and downslope disposal could contribute to large landslides, which would disturb or destroy hillside forest vegetation and alter local drainage patterns (Forest Service 1982a, p. 4-6). These slides could introduce large quantities of sediment and debris to the Blossom River or tributary streams, and expose disturbed areas to increased erosion, with additional sediment contributions to local drainages. Water quality impacts associated with sediment derived from slides and erosion are discussed in Section 4.1.5.

An important consideration for the project area is seismic stability. In a worst case assumption, a major seismic event could trigger failure of the water quality control ponds, resulting in impounded materials being released to watercourses. Seismic activity could also trigger landslides and rockfalls in areas of unstable slopes. However, it is anticipated that impoundments, embankments, and other structures would be designed and constructed to withstand the effects associated with seismic activity. Impacts associated with seismic activity should therefore be insignificant.

The high hazard (Class 3) avalanche areas would be primarily in the mine pit area, portions of upper Hill Creek, and portions of Tunnel Creek. A single avalanche event could affect relatively large portions of the construction or mining area in the vicinity of the pit, and

therefore involve loss of life. Accordingly, the impacts of avalanches during both the construction and operations phases are considered very significant.

Except for the pit area, significant project-induced landslides should largely be confined to the construction phase, since those slope and soil failures occurring during the construction period should result in relatively stable conditions.

It is recognized that susceptibility to landsliding, or slope failure, depends on a number of preexisting conditions within the environment such as drainage patterns, bedrock properties (including bedrock attitude, joint and fracture frequency and direction, bedrock competence, and pore pressure), slope geometry and aspect, soil properties (including composition, thickness, and degree of saturation), and vegetative cover. However, in the absence of sufficiently detailed field investigations to characterize these conditions for the entire project area, the assessment of landslide susceptibility was based on assessment of two conditions (slope and soil type) that could readily be ascertained from existing topographic and soil data bases. More importantly, these two factors appear to have a significant relationship to the incidence of, and the potential for, mass movement.

It should also be noted that several mitigation measures would be employed in order to minimize the impacts of landslides on the environment. These include the following:

- Revegetation of disturbed areas, cut banks, and side cast materials as soon as possible;

- Seeding and mulching of any landslide within 48 hours of occurrence;

- End hauling of landslide materials to an approved disposal site; and

- Use of special blasting techniques in landslide prone areas as appropriate, including test shots, and avoidance of blasting after heavy rains.

Permanent avalanche control structures and an active avalanche control program would be in place early in the construction phase and would afford a degree of protection to employees throughout the life of the project. The likelihood of an avalanche is still judged to be relatively high. Since such an event could involve damage to property, personal injury, and loss of life, potential impacts are considered very significant.

By the reclamation phase, soil and slope conditions are expected to have generally stabilized. Unstable slope conditions may continue to exist in the pit area, but the effects of failures in this area should

be confined to the pit. The workforce during the reclamation period would be limited, and it is assumed that they will not work during the winter season. Therefore, there would not be a significant avalanche hazard.

4.1.9.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

Landslide impacts and hazards would largely be confined to the construction phase. Townsite alternatives were identified in part on the basis that locations selected were in areas of relatively gentle slopes. Accordingly, landslide impacts are judged to be insignificant within the boundaries of the townsites. The access road from the Wilson-Blossom townsite areas would traverse gently sloping terrain, and relatively stable soil and slope conditions. Accordingly, landslide impacts for this townsite variant are expected to be insignificant. An access road from the Bakewell townsite would traverse some very steep, and often precipitous, terrain. Mapping of slope and soil conditions along this road alignment indicates a moderately significant to significant landslide hazard. Landslide impacts during the mining and postmining periods are judged to be similar to the proposed project and to be insignificant.

With regard to avalanches, the Wilson-Blossom townsites and the additional access roads are located in a relatively low hazard area. Therefore, hazards during the townsite and access road construction phase are low. The Bakewell townsite is also located in a relatively low-hazard avalanche area.

The Bakewell access road, however, traverses an area judged to be moderately susceptible to avalanches (Wilson 1980). During the construction period, worker exposure to avalanche hazards should be relatively low as it is possible that high hazard periods (for example during and immediately following a large snowstorm) can be avoided by flexible scheduling.

Worker exposure is expected to be highest during the mining period, in particular along the access road. Regular travel by workers through potentially high-hazard avalanche zones increases the probability of an avalanche event involving property damage, personal injury, or death. Impacts during this period are therefore judged to be very significant.

Other impacts of this alternative are essentially the same as for the proposed project.

4.1.9.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

Impacts of this alternative are essentially the same as described in Section 4.1.9.2.

4.1.9.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

Impacts of this alternative are essentially the same as described in Section 4.1.9.2.

4.1.9.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

Impacts of this alternative are essentially the same as described in Section 4.1.9.2.

4.1.9.7 Beaver Creek Mill with On-Land Tailings Disposal

Any sudden, large-scale failure of either of the tailings impoundment dams would be a major hazard. A very large flood and tailings sediment wave could travel quickly to the stream mouth, a distance of approximately 1 mi for Tunnel Creek and 2 mi for Aronitz Creek. Destruction would be severe to total along its path. A wave moving from the head down the fjord could also occur. The probability of such large-scale or complete failure of a properly designed, constructed, and maintained dam is extremely low. Seismic risk at the site is classified as low to medium.

Failure of a smaller part of the dam structure has a higher probability, and approaches inevitability as time increases if the structures are not inspected and maintained.

Other impacts of this alternative are essentially the same as described in Section 4.1.9.2.

4.1.9.8 North Meadow Mill with Boca de Quadra Tailings Disposal

Impacts of this alternative are essentially the same as described in Section 4.1.9.2, with the exception of impacts of a Keta townsite option. The Keta townsite is at a location that is adjacent to relatively steep slopes. However, since construction activities would be largely confined within the townsite boundaries, landslide impacts are judged to be insignificant.

An access road from the Keta townsite would traverse some very steep and precipitous terrain. Results of detailed studies of landslide hazards in this area (Keta access route) are contained in the Bulk Sample Access Road EIS (Forest Service 1982a, p. 4-4b, Table 4-7).

Placement of mill facilities at the North Meadow site would result in increased exposure of workers to avalanche hazards. Several Class 3, destructive avalanche zones occur in close proximity to the proposed mill site location. Worker exposure to avalanche hazards would be relatively low if high hazard periods can be avoided during the more flexible, project construction period.

The Keta townsite is situated in a relatively low hazard avalanche area; however, the townsite is within a short distance of several potential avalanche zones (Figure 3-16). The additional access road traverses several avalanche zones, some of which have been classified as potentially major destructive zones.

Worker exposure to avalanches is expected to be highest during the mining period, in particular along the access road. Regular travel by workers through potentially high hazard avalanche zones increases the probability of an avalanche event involving property damage, personal injury, or death.

Personnel exposure during the postmining period at the Keta townsite would be limited to individuals required for reclamation activities for the relatively short period of time necessary to complete mine reclamation. It is assumed that reclamation work would not continue through the winter season. It is also assumed that once reclamation has been completed, the mine access road would be closed to regular travel, and therefore travel from the townsite to the mine area would be restricted.

4.1.9.9 North Meadow Mill with On-Land Tailings Disposal

Impacts of this alternative are essentially the same as for the previous alternative.

4.2 CONSEQUENCES ON THE BIOLOGICAL ENVIRONMENT

4.2.1 Freshwater Ecology

4.2.1.1 No Action

If no further development takes place at Quartz Hill, the only potential impacts on freshwater resources would result from the existing bulk sample access road and mine adit sites.

If the access road is maintained, a small amount of sediment would continue to erode from the exposed road surface and backcut slopes. The amount of sediment produced would be relatively small compared to the natural stream load. Therefore, no significant impacts on the fish population are expected. However, if the road is not maintained (especially culverts), landslide potential would increase until vegetation becomes established. Slope failures associated with the road would likely occur for several years until a stable drainage pattern is developed. The potential effects of a landslide on fish in the Blossom River could be similar to or greater than the effects estimated for the landslide in No. 1 Creek (i.e., total loss of 24,604 adult salmon) (Appendix G, Table 5-2).

Water quality in White and Hill creeks would be slightly altered from natural conditions under the no action alternative because they would continue to receive water from the two mine adits. No effects on aquatic life in White or Hill creeks are expected because mine adit water was not acutely lethal to juvenile coho and did not inhibit seawater acclimation of smolts (EVS 1984b), and potentially toxic constituents would be diluted in White Creek.

4.2.1.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

The discussion of freshwater impacts from the proposed development of Quartz Hill concentrates on effects to the four major species of salmon (i.e., pink, chum, coho, and chinook), Dolly Varden char, and their habitat. Impacts on other anadromous and resident salmonid species are similar and can be inferred. Impacts of project components in fresh water are discussed by watershed for each alternative. Watersheds are discussed in order of descending severity of impact.

Tunnel Creek

The project would have the greatest impact on the aquatic life of Tunnel Creek. Construction and operation of the ore processing plant, power plant, camp housing, water storage reservoir, and access road could cause very significant impacts on both fish and their habitat. The power plant and processing mill require 36 cfs of water for cooling and the ore concentration process. Tunnel Creek is the primary water supply source. This water withdrawal has the potential to cause significant impact on the salmon populations in Tunnel Creek. Therefore, the timing and quantity of water withdrawals would be planned to meet instream flow requirements necessary to protect fish habitat.

Envirosphere (1987) examined four alternative heights for a dam on Tunnel Creek, including variations in pumping rates, instream flow requirements, and emergency water supply storage requirements. The results showed that streamflow requirements of the NMFS and USFWS (see Section 3.2.1) could be met with a 52-ft-high dam on Tunnel Creek, which would provide the primary water supply. This would be supplemented by withdrawals from the Blossom River. It is expected that these flows would maintain the necessary instream flow for salmon in Tunnel Creek.

Construction of the access road in Tunnel Creek is not expected to have a significant impact on fish resources. The planned stream crossings at stream mile 0.85 and 1.32 are located at the upper end of anadromous fish access (stream mile 0.87). Road construction in the stream would be conducted during a period (May 15-July 1) when fish are not spawning and sediment containment measures would be utilized. Blasting during road construction would not affect fish, as the road route is greater than 500 ft from the stream, except at the bridge crossings. The bridges are located in the stream floodplain where blasting is unlikely.

Stream crossings, road use, and encroachment of road and plant facilities on the stream channel could increase sediment loading to Tunnel Creek by 12 percent annually over baseline levels (Appendix E, Table I-4). Sediment runoff from a gravel road is composed of small, sand-size particles (<2.0 mm) that may accumulate in the salmon spawning gravels of Tunnel Creek (Cederholm et al. 1981). Streamflow regulation to provide water for the power plant and process mill could minimize the magnitude of storm events (Section 4.1.3) and reduce sediment flushing from the stream. Therefore, flushing flows required to maintain spawning gravel quality would be incorporated into the

final instream flow requirements. In addition, the use of high quality road surface materials and erosion control structures should reduce sediment impacts from those predicted as the worst case in Appendix E, Section I. Consequently, only minor impacts on fish or fish food organisms could be expected during project operation.

No additional impacts are expected from the power plant and mill during normal operations. All potentially hazardous effluent (i.e., heated water, chlorinated water, and mill reagents) would be collected in the process water pond and recirculated through the mill before disposal with the tailings.

Tunnel Creek would be vulnerable to spills of milling reagents hauled and diesel fuel carried by pipeline to the mill and power plant. Though the probability of spills is low, the potential for damage from a major spill is significant. Concentration of spilled chemicals could exceed threshold levels and cause severe mortalities to all forms of aquatic life. Potential biological effects of chemical and oil spills into project streams are discussed in Appendix G, Section 13.

Blossom River

Impacts from construction and operation at the mine site and mine service facility would be moderated by the presence of a water quality control facility in Beaver Creek. Water quality control facilities would be designed to treat drainage effluent to meet NPDES and ADEC standards. Therefore, sediment concentrations in the effluent would not exceed 30 mg/l during streamflows that do not exceed the 10-year, 24-hour flow event. Sediment concentrations less than 30 mg/l would not harm fish directly and would have an insignificant impact on the aquatic ecosystem (Iwamoto et al. 1978). Streamflows exceeding the 10-year, 24-hour flow event would contain an undetermined amount of suspended sediment. However, the effluent would be composed of silt size or smaller particles (see Section 4.1.6) that would be flushed through the drainage by the high flows. During large storms, suspended sediment concentrations may potentially exceed the lethal threshhold and result in the loss of juvenile salmonids rearing in Beaver Creek. Noggle (1978) reported 96-hr LC50 values (the concentration causing 50 percent mortality) for suspended sediment of 1,500 mg/l in summer and 30,000 mg/l in autumn for juvenile coho on the Olympic Peninsula, Washington, where water quality is similar to the conditions at Quartz Hill. Chum salmon tend to be more tolerant than coho, as Smith (1978) reported 96-hr LC50 values of 28,000 and 55,000 mg/l for fry exposed to two natural suspended sediment sources in estuarine water on Hood Canal, Washington. Lower Beaver Creek does not have any sizeable tributaries where fish may find refuge during a large storm event. Therefore, a complete loss of juvenile salmonids in Beaver Creek has the probability of occurring once every 10 years, with each loss comprising a total of 23 adult salmonids. If Beaver Creek is currently underseeded, due to excess oceanic harvest of adults, which is possible for this salmon species, the total loss would be higher (Appendix G, Table 4-1). In many flood situations, however, the Beaver Creek dam

may moderate flow regimes to reduce suspended sediment and its adverse impacts on fish populations. Through such flood regulation, the dam may provide a positive impact.

Impacts to fish in the Blossom River are not expected, as high concentrations of suspended sediment in Beaver Creek would be diluted by the Blossom River, which has 21 to 38 times more flow than Beaver Creek (computed from Appendix Table D-2). Also, juvenile salmonids seek refuge in tributaries, side channels, and sloughs during peak streamflows (Bustard and Narver 1975; Peterson 1980; Cederholm and Scarlett 1982) and would not be affected by potentially high concentrations of suspended sediment. Effects on eggs incubating in the stream gravel would be minor, as it is unlikely that silt from the water quality control facility would settle in the river during a large storm event.

Supplemental water withdrawal from the Blossom River (via a filter bed in the streambed) is not anticipated to result in any significant impacts (see Section 4.1.3.2).

Water supply requirements at the mine site would require removal of a small quantity of water (0.15 cfs) from tributaries of Beaver Creek. The impact of water withdrawals on fishery resources in lower Beaver Creek would be insignificant during average flow conditions, but significant during extreme low flow periods. Under natural conditions the 10-yr, 7-day low flow (0.6 cfs, Table 3-3) at the mouth of Beaver Creek causes a reduction in fish habitat that probably results in a significant impact on the fish population. During project operation after year 6, water withdrawal plus drainage of pit water into Hill Creek would reduce the 10-yr, 7-day low flow to 0.5 cfs (Appendix D). This flow reduction would magnify the effects of a naturally low flow and result in a moderately significant impact on fish. However, fish populations are small and under worst case conditions if all fish were destroyed the average loss would equal 23 adults (Appendix G, Table 4-1).

A breach of the water quality control dam, as a result of an earthquake or other unforeseen event, while very unlikely, would cause very significant damage to fish populations and habitat in the Blossom drainage. The large volume of water and sediment released from the pond would constitute a mudflow that would cause severe scour and deposition in the Blossom River. All fish and incubating eggs in the river at the time of the mudflow would most likely be destroyed. Fish production following the event would be very low for several years to decades, depending upon species and the rate of habitat recovery.

Widening of the mine access road to 36 ft would generate sediments that could have a moderately significant impact on salmon in the Blossom River. During construction of the original access road, landslides induced by blasting resulted in the deposition of 243,255 ft^3 of soil material into Raspberry and No. 1 creeks (Lyons 1984, Table 2). The majority of this material (242,000 ft^3) was subsequently flushed into the Blossom River by freshets during autumn (1983) and high flows

during spring snow melt. Immediately after the landslide into No. 1 Creek occurred (November 5, 1982), fine size particles (<4.0 mm) in the spawning gravel of the Blossom River, 1 mi downstream of No. 1 Creek, increased from an average of 12 percent to 18.5 percent (VTN 1983b; Appendix G, Figure 6-1). Several weeks after the landslide, the average concentration of fines dropped below 12 percent, but samples collected in March indicated that fines increased to 17.5 percent (Appendix G, Figure 6-1). Therefore, the landslide caused temporary increases in intragravel sediment concentration during the salmon egg incubation phase and may have reduced egg survival to emergence.

An evaluation of the landslides induced by construction of the bulk sample access road indicated that implementation of a controlled blasting program significantly minimizes the potential for landslides. But, landslides could not be totally eliminated because of the extreme steepness of slopes along the access route (Lyons 1984). Therefore, widening of the mine access road would have a high probability of causing some landslides. Under the worst conditions, the volume of material that may reach the Blossom River could equal the amount produced during construction of the bulk sample access road. Increases of sediment in spawning gravels would presumably be similar to the levels measured (18.5 percent) following the landslide into No. 1 Creek. Since road construction occurs during the summer period, the resulting increase in sediment would occur shortly before or during the period for salmon spawning and egg incubation. Clogging of spawning gravel and subsequent mortality of incubating salmon eggs could cause a total loss of 24,604 adult salmon from the Blossom River (Appendix G, Table 5-2). Therefore, at current harvest levels the commercial salmon fishery could lose an estimated 16,413 salmon (i.e., 15,351 pink, 333 chum, 598 coho, and 231 chinook) and the sport fishery 17 salmon (i.e., 11 coho and 6 chinook). Since the construction phase would only last for 1 to 2 years and potential sediment inputs would be flushed out within 1 year by high streamflows, fish would only be vulnerable to sediment impacts for a short period.

Increased sediment from landslides could reduce the population of benthic macroinvertebrates and subsequently affect the food supply for rearing juvenile salmon. However, the effects on the salmon population would likely be minor, as the recovery of benthic invertebrates to sediment flushing is rapid (see reviews in Iwamoto et al. 1978); and a reduced fish population due to egg mortality would have a low demand on the food supply.

The potential effects of blasting on fish during road widening are unlikely. The access road route is not close enough to fish habitat except between stations 108+00 and 152+00, where the roadway ranges from 225 ft to 450 ft away from the lower Wilson River (Forest Service 1982a). The Tunnel Creek crossing would not require any additional blasting, as the original bridge construction was designed for

upgrading to a two lane bridge. Since the egg life stage of salmon is the most sensitive to shock, all blasting near fish habitat would occur before spawning occurs (i.e., May 15 to July 1). Thus, the potential for impacts on fish would be eliminated.

After the access road is widened, daily road use and continued erosion of backcut slopes could generate up to 1,300 tons (Appendix E, Section I) of sediment (<2.0 mm) per year that would enter the Blossom River through road ditches and small tributaries. Depending upon the frequency and magnitude of storms, sediment could accumulate in the spawning gravel. Sediments from logging roads and land use have caused an accumulation of fines in the spawning gravel of the Clearwater River, Washington, which has similar hydrology to Quartz Hill (Salo and Cederholm 1981). Similarly, an accumulation of sediment from logging in Carnation Creek, Vancouver Island, markedly reduced egg-to-fry survival of chum and coho salmon (Scrivener and Brownlee 1982). The landslides caused during road construction deposited 533 tons of sediment into the Blossom drainage (Section 4.1.5.2). Therefore, the impacts of 1,300 tons of sediment input during a year of low streamflow could equal losses (i.e., 24,604 adult salmon) predicted for a major landslide. Impacts from road use would occur intermittently with a probability of occurrence equal to the probability of low streamflows.

If runoff from the mine site and waste rock pile into the Beaver Creek water quality control facility contains biologically harmful pH and toxic concentrations of cadmium, copper, and lead, effluent water would be treated to meet both NPDES effluent limitations at the point of discharge and Alaska receiving water quality standards at acceptable mixing zone boundaries (Section 4.1.5.2). Water quality standards are designed to prevent significant bioaccumulation of toxic elements and to maintain aquatic productivity at natural levels. Consequently, no impacts on fish and aquatic productivity from sediment pond operation are expected in Beaver Creek or the Blossom River.

Spills of petroleum products and explosives could reach the Blossom River from several tributaries. Although the probability is low of a major spill occurring or reaching the streams and ultimately the Blossom River, a major spill could have significant impacts, not only to the tributaries, but potentially the Blossom River itself (Appendix G, Section 13).

Keta River

Construction and operation at the mine site, waste rock pile, and White and Hill creek water quality control ponds would have a moderately significant impact on fishery resources in Hill Creek and the Keta River. Operations would destroy all resident fish populations and habitat in White Creek and Hill Creek above the final water quality control dam, located upstream of the anadromous fish barrier in Hill Creek. Resident Dolly Varden char, the only salmonid species present in upper Hill Creek (density 0.11 fish/m^2 in July 1980; VTN 1980b, Table 3.2-5), currently are not exploited by a sport fishery.

Water quality control facilities in White and Hill creeks are designed to comply with NPDES standards for sediment control. Therefore, no impacts on anadromous salmonids are expected when streamflows do not exceed the 10-year, 24-hour flow event. However, when streamflows exceed the 10-year, 24-hour event, the water quality control facilities can only provide partial treatment. In such cases, the suspended sediment may exceed standards; suspended sediment exceedances could, as a worst case, result in the loss of rearing juvenile salmonids in lower Hill Creek. Loss of all anadromous salmonids in Hill Creek would comprise 287 adults (Appendix G, Table 4-1).

Since Hill Creek has a significant amount of habitat for spawning and rearing below the waterfalls, minimum streamflows should be maintained below the water quality control ponds. The ponds are planned to be operated in a manner that will not change volume of outflow. Thus, no flow-related impacts on fish or habitat are expected in lower Hill Creek or the Keta River.

As with water passing through other water quality control ponds, if necessary, potentially harmful pH and toxic metals would be treated to comply with NPDES standards. Effluent wastes would not be toxic to aquatic life and the potential for significant bioaccumulation would be avoided.

A breach of the water quality control dam in Hill Creek, while very unlikely, would cause very significant damage to fish populations and habitats in the Keta River. Fish population recovery after such an event could require several years to decades, depending upon the species and the rate of habitat recovery.

Other Water Supply Alternatives

Wilson River

This alternative is no longer part of the proposed project as described in the RDEIS. It has been replaced with a supplemental water supply from the Blossom River. Soil disturbance during construction of a well field, water line, and 2-mi-long access road would cause a short term, small input of sediment to the Wilson River. The road route is located on an alluvial floodplain that would require fill material for construction of the road bed. Therefore, some off-channel rearing habitat along the east bank of the river would be buried. Impacts to fish habitat would be minor and potential impact on fish is expected to be insignificant.

Removal of water from the Wilson River well field for mill processing and power plant needs could have an impact on streamflows and fish habitat. Water withdrawal would occur passively along a section of river bordering the wells, resulting in a reduction in streamflow in a 4 km section of river between the well site and the confluence with the Blossom River. This section of river is extensively utilized for spawning: in 1981 and 1982, 82 percent and 85 percent of pink salmon, respectively, and 62 percent and 23 percent of chum salmon, respectively, spawned in this reach (Table 3-11). The results of an

instream flow study conducted by the USFWS indicated that the potential impacts on fish would depend on the timing and magnitude of water withdrawal.

During the spawning season (July 1 through November 30) streamflow is adequate to meet or exceed the needs for the following: (1) fish passage for chinook, coho, pink, and chum salmon; (2) rearing habitat for chinook and coho salmon; (3) spawning habitat for pink salmon; and (4) water demands by mining operations. The flow volume meets or exceeds the maximum streamflow requirements of the above life stages 63 percent of the time during the summer spawning season. Without water withdrawal, fisheries requirements would be met 66 percent of the time. The median flow during the spawning period (i.e., 1,000 cfs) exceeds the optimum 770 cfs spawning flow (Table 4-11). Under these conditions the impact of water withdrawal during the summer spawning period in the Wilson River would be insignificant.

Effects of water withdrawal on salmon habitat are more significant during the winter incubation low-flow periods. Assuming that in any given year the natural incubation flow is 200 cfs and U.S. Borax withdraws an additional 36 cfs for mine operations, the effective incubation-spawning habitat for that year will be decreased from 28,900 ft^2/1,000 ft to 25,200 ft^2/1,000 ft or 13 percent (Table 4-11). Approximately 94 percent of the pink salmon population spawns in the 2.0 mi of river extending from the upper end of the proposed well field to the head of Wilson Arm (VTN 1982). Thus, water withdrawal during this period could reduce spawning and incubation habitat. Maintaining an instream flow requirement of 225 cfs would prevent reductions in effective habitat. However, during extremely dry and/or cold years, mining operations would have to be discontinued for up to seven weeks. Habitat losses within the 175 to 225 cfs flow range are from 10 to 15 percent. Given the general level of precision of the PHABSIM calculations, losses of this magnitude cannot be conclusively associated with significant effects on salmon populations.

This alternative includes a proposed minimum flow of 100 cfs. Water withdrawal of 36 cfs during a period of time when the natural discharge ranges from 125 to 150 cfs would cause a reduction in habitat ranging from 9 to 27 percent, respectively (Table 4-11). Habitat losses of this magnitude could have a significant effect on the production of salmon in the Wilson River.

Optimum rearing habitat and flow conditions for juvenile salmonids (greater than 1 year old) in the main channel of the Wilson River are higher than those for the fry (less than 1 year old) salmon. Optimum rearing habitat is achieved with flows of 250 cfs and 100 cfs for juvenile coho and chinook salmon, respectively. These conditions fall within the range of the naturally occurring incubation flows and below the summer flows. With a project water withdrawal of 36 cfs, adverse impact to the rearing habitat is not expected.

TABLE 4-11

IMPACT OF MINE WATER WITHDRAWAL ON PINK SALMON HABITAT WITHIN AND BELOW THE WILSON RIVER WELL FIELD

Incubation Flow (cfs)	Total Spawning-Incubation Habitat, EWUA 1/ (ft^2)	Water Withdrawal (cfs)	Flow Balance (cfs)	Residual Habitat, EWUA 1/ (ft^2)	Percent Loss, EWUA
250	331,100	36	214	319,600	3
225	331,100	36	189	291,900	12
200	305,000	36	164	265,800	13
175	275,400	36	139	253,300	8
150	253,600	36	114	230,900	9
125	253,000	36	89	184,000	27
100	203,000	36	64	139,000	31

1/ At 1,040 cfs spawning flow.

Raspberry Creek Reservoir

The impoundment and removal of water from Raspberry Creek could have a significant impact on fish and fish habitat in the lower reaches of this stream. Approximately 0.2 mi of habitat is utilized by salmon, trout, and char in lower Raspberry Creek. If minimum streamflows are not maintained, less habitat would be available resulting in a reduction in the productive capacity of the stream. Since Raspberry Creek is a small stream, it is possible that the stream discharge could be reduced to zero during the annual low-flow period. In this worst case, a complete loss of fish production would be equivalent to an annual loss of 74 adult salmon, trout, and char (Appendix G, Table 4-1). On the other hand, the impacts of natural low-flow periods could be minimized or eliminated if flows were supplemented by releases from the Raspberry Creek reservoir. An instream flow study would be needed to determine flows necessary for maintaining fish habitat.

Upper Hill Creek Reservoir

A dam in upper Hill Creek could have a significant impact on resident Dolly Varden char in upper Hill Creek and anadromous salmonids below the waterfalls. The dam and reservoir may destroy all resident fish populations and habitat in upper Hill Creek. Lower Hill Creek has 0.6 mi of habitat, which annually produces more than 250 adult salmon and char (Appendix G, Table 4-1). The potential impact of water withdrawal could range from nil to a complete loss of this stream's productive capacity depending upon whether or not minimum flows are

maintained. If this water supply alternative is chosen, an instream flow study would be needed to determine minimum flows necessary for maintaining fish habitat.

North Meadow Reservoir

The North Meadow reservoir would be located on both upper Hill Creek and upper North Creek. Therefore, potential impacts from this water supply alternative would be similar to those described for the upper Hill Creek reservoir.

Upper Lakes Reservoir

Withdrawal of water from the upper lakes would have no impact on fisheries resources. No fish are known to inhabit these lakes and the outlet stream is too steep for fish habitat.

Tunnel Creek as Sole Source

If this option is used, the reservoir on upper Tunnel Creek will be increased in size to supply all water needed for the project. Impacts to the aquatic environment will be much the same as those discussed in Section 4.2.1.2 resulting from reduced flow in Tunnel Creek. The need for a supplemental water supply from the Blossom River would be eliminated.

Temporary Shutdown

If the mine operation was shut down temporarily as a result of economic conditions or equipment failure, the potential impacts on fish would be similar or less than under the planned operation. Since all environmental compliance work would continue, no additional impacts on the aquatic environment would be expected.

Reclamation Phase

Removal of all mine facilities and reclamation of the mine site and access roads by seeding, planting, and recontouring would stabilize the area and reduce sediment inputs to Tunnel Creek, Blossom River, and Keta River. After a vegetative cover is established, erosion and subsequent sediment input to all streams would return to natural background levels. Any effects from sediment on fish production would diminish in frequency and magnitude to natural levels. Since the sedimentation control structures would be stabilized after sediment production has stopped, no further impacts on fish would occur.

4.2.1.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal with Upper Hill Creek Diversion and Townsite

Potential impacts from this alternative include those discussed in Section 4.2.1.2 with additional impacts from construction and use of a townsite, and from the diversion of upper Hill Creek.

Construction of a townsite at Bakewell Arm would cause a temporary increase in sediment in the lower Bakewell River. Inputs of sediment are expected to be very small as a result of the relatively flat topography of the townsite, low potential for landslides, and close proximity to saltwater. Therefore, no significant impacts on freshwater aquatic resources are expected.

Construction of a townsite at the Wilson I site would require an extensive amount of cutting and filling. Sediment inputs to the lower Wilson River could be large enough to cause impacts on aquatic resources unless sediment control measures are used. A total of 6 percent (see Table 3-11) of the available spawning habitat utilized by pink salmon in the Wilson River is located downstream of the proposed townsite. Sediment inputs during spawning or egg incubation could result in small loss of pink salmon.

The Wilson II townsite would be located above the river floodplain, thus no significant impacts on the aquatic environment are expected. However, the town access road would cross a number of side channels and sloughs used for rearing by juvenile coho and Dolly Varden char. Fill required to build the road would inundate some rearing areas and destroy the production potential of these habitats.

During occupation of the townsites, pollution from nonpoint sources (e.g., sediment, oils, and grease) would enter streams and rivers and cause some degradation of aquatic habitat. However, potential impacts on fish in the freshwater environment would be minor, since the townsites are located very close to saltwater. Impacts from domestic sewage on fresh water will not occur, as outfalls are planned to discharge into saltwater or into sanitary drain fields.

Long-term impacts from a town located at the project would stem primarily from increased sport fishing. Fishing would probably be one of the primary recreational activities for residents of the townsite. The number of residents that would fish cannot be predicted, but based on license sales in the Stikine area, a town of 1,500 people could result in the sale of 450 sport fishing licenses (Schmidt et al. 1977). Coho and chinook salmon populations are currently depressed in the project area (Gray 1983; Kissner 1983); thus, additional fishing could have a significant impact on these stocks. On the other hand, pink and chum salmon populations are currently underexploited (Schmidt et al. 1977) and could support a substantial sport fishery with little impact on the local stock. Dolly Varden char and cutthroat trout populations are also unexploited and could support a sport fishery. Populations of steelhead in the area are small and would be vulnerable to overfishing and potential loss of the stock. The level of exploitation that could be sustained would depend upon the condition of each stock. Overexploitation of the local stocks could be prevented through annual stock assessments and regulation of catch. The ADF&G would be responsible for the protective management of stocks and maintenance of a productive fishery.

The diversion of upper Hill Creek into North Creek would approximately double the average streamflow at the mouth of North Creek (Appendix D). This large increase in flow would cause significant disruption to channel morphology for several years until channel capacity is enlarged to compensate for the new flow regime. During the period of morphological adjustment the channel would be very unstable, contain high loads of sediment, and become unsuitable for fish production. A complete loss of fish production would be equivalent to an annual loss of 19 adult salmon (Appendix G, Table 4-1). After the channel stabilizes and habitat begins to recover, the increased streamflow may result in more fish habitat and fish production than was present before the diversion of upper Hill Creek. Impacts from sediment in the Blossom River would be minor, unless the increased flow caused slope undercutting in North Creek that could cause landslides. In the latter case, sediment input to the Blossom River could be large and could result in very significant impacts on fish. An assessment of landslide potential and estimates of sediment production would be necessary before the potential impacts on fish could be evaluated.

The effects of diverting water out of upper Hill Creek would cause a 17 percent reduction of streamflows in lower Hill Creek during the 10-yr, 7-day low flow event. However, the diversion is unlikely before year 20 because the waste rock pile would not encroach upon Hill Creek until that time. Since mine pit drainage would increase flows in Hill Creek (1.7 cfs) after year 6, the loss of water as a result of the diversion (low flow reduced by 0.8 cfs) would have an insignificant impact on streamflow and fish habitat.

All impacts after project closure are the same as discussed in Section 4.2.1.2.

4.2.1.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The access road to the Tunnel Creek mill would be widened by 8 ft to accommodate the tailings pipeline. The additional 8 ft disturbed area would increase sediment input to Tunnel Creek during construction, but the increase in sediment input would be small relative to that stemming from construction of the proposed road, power plant, and mill. Therefore, impacts to the fishery resource other than those described in Section 4.2.1.2 are not expected.

Long-term impacts from the tailings pipeline along the access road would be limited to soil erosion from the exposed corridor. Additional erosion is considered insignificant relative to the sediment from road use. Impacts other than those described in Section 4.2.1.2 are not expected in Tunnel Creek.

The consequences of a break in the tailings pipeline along Tunnel Creek would depend upon the location of the spill and failure of the spill containment facilities. Even a small spill that entered Tunnel Creek is likely to cause significant effects on the fish population due to extreme sedimentation and suspended solids concentrations. In the

worst case, if the spill occurred during the egg incubation phase, all salmon production (average 27,397 adults, see Table 3-10) in Tunnel Creek could be destroyed. However, the likelihood of a pipeline rupture combined with a spill containment system failure is exceedingly small. Assuming the monitoring and maintenance of tailings pipelines are effective, and that spill trenches, catch basins, and enclosure pipes function properly, the probability of serious impacts to regional fisheries is considered insignificant (see Appendix G, Section B for an expanded risk assessment).

All impacts after project closure are the same as discussed in Section 4.2.1.2.

4.2.1.5 <u>Beaver Creek Mill with Boca de Quadra Tailings Disposal</u>

Power Plant at Beaver Creek

Under this alternative no development would occur in the Tunnel Creek drainage. Therefore, impacts to fish would not occur in Tunnel Creek.

Sediment during construction and operation of all facilities at Beaver Creek would be contained by the Beaver Creek water quality control pond. Sediment and chemical concentrations in lower Beaver Creek and Blossom River would not change from those described in Section 4.2.1.2, and additional impacts are not anticipated.

Diversion of water from Raspberry Creek for mill and power plant needs would significantly reduce streamflow in lower Raspberry Creek. Unless minimum streamflows are maintained for Raspberry Creek, the spawning and rearing habitat (0.2 mi) for anadromous salmonids in the lower portion of the stream would be eliminated. This would result in an estimated annual loss equivalent to 74 adult salmonids: 35 coho, 10 chinook, 28 Dolly Varden, and 1 steelhead (see Appendix G, Table 4-1). The loss of coho and chinook to the commercial fishery would be expected to be 80 percent of the estimated annual loss, or 36 adult salmon.

Construction of the tunnel portal and pipeline at the mouth of the Keta River could cause a short-term impact on fish habitat from sediment input. Impacts on fish and aquatic food organisms would be insignificant.

A rupture of the tailings pipeline could have very significant impacts on aquatic life in the Keta River and localized impacts on benthic organisms in the estuary and Boca de Quadra, depending on the location and severity of the break. Concentrations of suspended sediment could be above concentrations acutely lethal to juvenile salmon. Estimates of impact are discussed in Appendix G, Section 16.

Power Plant at Tunnel Creek

Impacts to fish in Tunnel Creek depend upon whether the power plant cooling water is pumped to the Beaver Creek mill, or cooling water is discharged into Tunnel Creek after treatment to remove chlorine and trace metals and to lower water temperature. In the former case, impacts on Tunnel Creek would occur from dewatering of fish habitat unless minimum flows are maintained as described in Section 4.2.1.2. In the latter case, all cooling water, excepting a 1 cfs loss due to evaporation, would be returned to Tunnel Creek and no impacts on fish are expected.

Project Closure

All impacts on freshwater resources are the same as described in Section 4.2.1.2.

4.2.1.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

Widening the access road by 8 ft to accommodate the tailings pipeline would not create additional impacts during construction, but would increase sediment impacts to the Blossom River over the long term. Construction impacts to fisheries are expected to be similar in probability and magnitude to that described in Section 4.2.1.2 for the access road. On a long-term basis, the additional exposed area could increase erosion, sediment production, and landslides from the road/pipeline corridor. The rate of sediment accumulation in spawning gravels of the Blossom River might be accelerated, thereby increasing the probability of impact somewhat above that described in Section 4.2.1.2. Intragravel sediment concentrations might not exceed 18.5 percent, but the frequency at which these concentrations are reached before being flushed could be greater.

Placement of the tailings pipeline along the Blossom River access road increases the probability of pipeline spill as a result of proximity to traffic, avalanches, and landslides. The pipeline would be placed in a ditch and spill containment structures are planned. However, if the pipeline ruptured and containment structures failed, the magnitude of an impact on fish and their habitat would depend upon the location of a pipeline break and the life history stage of each salmonid species at the time. A spill near Beaver Creek would release less tailings, but impact a greater length of river, whereas one near the estuary would release the maximum quantity of tailings but impact a smaller area of river. Potential impacts on the fishery resources in the Blossom River could be lethal to eggs or juvenile salmonids (Appendix G, Section 16).

The Raspberry Creek water supply reservoir would have the same impact on habitat and fish as that described in Section 4.2.1.5.

All impacts on freshwater resources after project closure are the same as discussed in Section 4.2.1.2.

4.2.1.7 Beaver Creek Mill with On-Land Tailings Disposal

On-land tailings disposal in Tunnel and Aronitz creeks would eliminate fish production in both streams. The tailings pond and retention dam would inundate all fish habitat above the retention dam site. In Tunnel Creek, approximately 0.2 mi of stream would be available below the outlet spillway tunnel (Figure 3-5). However, fish habitat in this reach would be limited, because tailings decant water would be pumped back to the mill for reuse. During the annual low flow period (January-March) all fish habitat would be eliminated, unless minimum flows necessary to protect fish habitat are provided. Assuming the worst case, the average annual loss of fish would be equivalent to 27,397 adult salmon: 25,557 pink, 1,645 chum, 166 coho, and 29 chinook (see Table 3-10). In Aronitz Creek, all anadromous fish habitat below the dam would be unusable, as the outlet spillway discharges directly into saltwater. Average annual loss of fish would be equivalent to 2,860 adult salmon: 2,157 pink, 686 chum, 16 coho, and 1 chinook.

On-land tailings disposal would require construction of a tailings pipeline across the Keta River and along the east side of the estuary. Soil disturbance would cause a short-term increase in sediment that could have a moderately significant impact on spawning gravel quality in the lower Keta River.

The tailings pipeline to Tunnel Creek would have the same impacts on the fishery resource as that described for the Beaver Creek mill with Wilson Arm tailings disposal.

The consequences of a tailings pipeline break along the Blossom or Keta rivers would depend upon the location of the break and time of year. Under a worst case, a major portion of the salmon production in either the Blossom or Keta river estuary could be lost as a result of exposure to high suspended sediment levels (Appendix G, Section 16).

All impacts on freshwater resources after project closure are the same as discussed in Section 4.2.1.2.

4.2.1.8 North Meadow Mill with Boca de Quadra Tailings Disposal

Impacts to Tunnel Creek fishery resources would not occur, and the Blossom River access road would be reclaimed, thus eliminating long-term sediment impacts. Impacts from water withdrawals would not occur in either the Blossom River or Raspberry Creek.

Sediment from potential landslides during road construction could increase sediment loads in the Keta River and result in impacts on salmon production. The potential sediment impacts on spawning gravel quality would be short term (i.e., 1-2 years during construction) and assumed equivalent to landslide effects measured in the Blossom River (see Section 4.1.2.2). A reduction in spawning gravel quality (i.e., sediment, <4 mm, increased to 18.5 percent) could cause egg mortality that would result in short-term fish losses equivalent to 38,616 adult salmon per year (Appendix G, Table 5-3). At current harvest levels,

the commercial fishery could lose an average of 25,843 salmon (18,186 pink, 6,590 chum, 590 coho, and 477 chinook) and the sport fishery loss could average 23 salmon (11 coho and 12 chinook).

During mine operation, sediment from road use and erosion could increase the annual sediment load in the Keta River by 7 percent over background levels (Appendix E, Section I). Over the long term, intermittent accumulations of sediment during low flow years could reach the 18.5 percent level and result in egg mortality equivalent to losses estimated for a landslide.

Power plant and process water for the mill would be supplied from an upper Hill Creek reservoir and the Hill Creek water quality control pond. Prior to year 6, while the mine pit drains into Beaver Creek, water withdrawals from upper Hill Creek would reduce streamflows in lower Hill Creek by 17 percent during the low flow period (Appendix D). Therefore, water withdrawals could impact fish habitat in lower Hill Creek below the barrier falls unless minimum flows are maintained. Without minimum streamflows, the annual loss in Hill Creek would average 104 coho, 34 chinook (Appendix G, Table 4-1), and an undetermined production of pink and chum salmon.

The construction and occupation of a townsite located along the lower Keta River would cause a small increase in sediment that is not expected to have a significant effect on freshwater resources. However, the presence of a town would increase sport fishing and likely result in similar impacts as described in Section 4.2.1.3.

All impacts on freshwater resources after project closure are the same as discussed in Section 4.2.1.2.

4.2.1.9 North Meadow Mill with On-Land Tailings Disposal

Impacts on freshwater fishery resources would be similar to those described for the North Meadow mill with Boca de Quadra tailings disposal, with additional impacts to resources in Tunnel and Aronitz creeks as described for the Beaver Creek mill with on-land tailings disposal.

All impacts on freshwater resources after project closure are the same as described in Section 4.2.1.2.

4.2.2 Marine Ecology

These sections address impacts to the marine environment with respect to EPA's ocean discharge criteria (40 CFR Section 125.122). Items from these criteria that are addressed include bioaccumulation, transport by biological components, vulnerability of the biological communities and effects on important food chain organisms, effects on spawning and rearing habitats, and effects on recreational and commercial fisheries. Other items from these criteria are discussed in Section 3.2.2.

4.2.2.1 No Action

With this alternative the bulk sampling road and wharf area can still be retained and used by U.S. Borax. Some continuous road and wharf sediment runoff can occur above ambient runoff conditions. The quantity is assumed to be reduced from the present bulk sampling activities, and would have insignificant impacts on the marine environment in Wilson Arm/Smeaton Bay. The potential for hazardous substance spills (e.g., oil) would also decrease with reduced activity in this area. The result would be a decrease in the potential for release of toxic substances to the marine environment.

4.2.2.2 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Inner Basin and Commute Option

This alternative considered two tailings discharge options, direct discharge to the inner basin and movement of the tailings pipe from the inner to the middle basin after an undesignated period. The following discussion focuses on the first option. The second option is discussed at the end of this section.

Construction Phase Impacts

During the construction phase, with both discharge options, some direct physical loss of marine habitat by burial in Wilson Arm/Smeaton Bay would occur. The largest inundation of marine habitat from construction would result from an increase in road width and expansion of the wharf area.

The present bulk sampling road courses along the edge of the estuary for 0.7 mi. Its widening would directly inundate an additional 1.5 ac or 0.5 percent of the original 320 ac of tidelands in the estuary. Loss of any invertebrates would be a small proportion of the estuary's production. Moreover, any tidal channel habitat that is used by pink, chum, and coho salmon for rearing in the spring and summer (Forest Service 1982a) that is lost as a result of estuarine alteration would likely be replaced by a new channel. The loss of part of a tidal channel that was covered by the original access road has been replaced by a new channel that formed by erosion of an existing sedge bank. Because of these factors, burial of this habitat would not have a significant impact on important marine resources.

The access road from the Tunnel Creek turnoff to the wharf area would be expanded with an additional 5,000 cu yd of shot rock and fill placed on the intertidal habitat; this equals about 0.2 ac of nearshore habitat. The wharf expansion would be located about 0.5 mi from the estuary tideflats, and consist of floating docks supported by pilings. The only burial of habitat from wharf area expansion would be from a temporary barge grounding area (0.5 ac) and a permanent boat launch (0.13 ac).

The area that would be filled by the barge grounding facility, boat launch, and outer access road constitutes good juvenile salmon habitat during the spring and summer (VTN 1982e). Additionally, important prey items (e.g., amphipods, harpacticoids) for salmon and herring and other important marine species would be directly lost from the area being filled. This area is generally steep and rocky and would not be significantly altered with this fill. Except for the boat launch area, the nearshore habitat would remain about the same after the fill. This area should be recolonized within a year with similar abundance and species composition as that present prior to construction. The barge grounding area is temporary and would be removed after all major construction is completed. Although some loss of benthic and epibenthic organisms would occur during construction, the net effect on the upper Wilson Arm important marine resources should not be significant due to the small area occupied by the road, wharf, and other facilities and recolonization of the area filled.

Because no major bulkheads would be made to potentially force juvenile salmon into deeper water, no impacts on salmon movement along the shore would occur. Some permanent reduction in benthic algae productivity and in benthic organisms that feed on them may occur from shading of the barge area (200 x 50 ft) and floating dock (250 x 30 ft). The small size of the area relative to the total nearshore habitat indicates that this area would have no significant effect on important organisms such as salmon and herring that rely on nearshore organisms.

Construction of the tailings discharge line into Boca de Quadra would have no significant impacts. Excess waste rock from tunnel excavation would be deposited in the fjord equaling an area of about 1 ac at 30 ft deep. Some initial burial and loss of organisms would occur. Because of the steep side walls most rock should be deposited into the deep part of the fjord, resulting in only temporary disturbance in the photic zone (upper 30 m). Installation of a mixing chamber and scour plate would cause local turbidity, but this would be short term. The small size of the area disturbed and covered permanently would not result in significant impacts from their placement.

The effects of pressure waves from road construction and wharf area excavation is also a concern. The most severe effects of blasting in water are on fish having air bladders; only minor effects would occur on those without air bladders (Hill 1978, p. 24). Fitch and Young (1948, p. 58) also found that explosions just under the sea floor were only 15 percent as lethal to fish as those in the open water. This was the result of a more rapid attenuation of the pressure wave in sediment than in water. The main effect is from a sharp pressure wave emitted by some types of explosives. Hill (1978, p. 26) states that pressure waves in water also damages fish eggs and larvae. Although not directly comparable to the marine environment, the Forest Service (1964, p. 6) found no measurable harm to pink salmon eggs 160 ft from a 3.5 to 4.5 ton dynamite blast similar to those used in road building. Underwater explosives were not found to drive fish out of the area (Fitch and Young 1948).

No underwater dynamite blasting is planned, so direct effects in the area would not occur. Some blasting would occur in the vicinity of the wharf when 330,000 cu yd of soil and rock were removed. Although charges would be high (several hundred pounds), attenuation of the pressure wave by the rock should result in no mortalities, but care should be taken to limit blasting close to the water, particularly during the spring and summer period when juvenile salmon are near shore.

Sediment input to Wilson Arm/Smeaton Bay from access road construction would increase measurably. Input to the Wilson River (the Blossom River plus Wilson below their confluence) from landslides caused by access road construction and road runoff is anticipated to reach about 7 percent over natural levels within the first one to two years after construction (Appendix E, Section I).

Fine particles (sand or smaller) from landslide material would enter the river within a year. All fine particles are assumed to enter the estuary within the first year, with larger particles entering over several years. Therefore, for the first year of construction some 3,700 tons (2,800 tons landslide material plus 900 tons from one half year road runoff) of fine sediment could move down the river (Appendix E, Section I).

The amount of sediment is not expected to cause either short- or long-term impacts on bottom dwelling invertebrates. The 3,700 tons of sediment that may be exported the first year of construction could cover the estuary with a layer that averages no deeper than 0.20 cm (see Appendix G, Table 8-1). For the purpose of calculation it was assumed that all sediment would be deposited uniformly only on the estuary and a whole year's worth of sediment would be deposited instantaneously.

Sedimentation of this amount is probably not enough to cause significant mortality in bottom dwelling invertebrates except in small areas where large amounts may be deposited (Turk and Risk 1981). Moreover, benthic organisms currently living in the estuary are exposed to episodes of heavy sedimentation: 25 percent of the total annual sediment load can be deposited in one month (Burrell 1983, p. 13). About 25 percent of natural annual load equals about 400 percent of the expected increase. Additionally, deep water benthic life should remain unaffected by increased riverine loading of sediments.

Furthermore, should benthic life be smothered by natural sediments, recolonization could be rapid (Barrett and Rosenberg 1981). The rate of recolonization is dependent on the time of year. During the warm summer months it would occur in weeks, while in the winter it may take months. The most critical period would be during the spring and summer when juvenile salmon are feeding on benthic organisms such as chironomids or harpacticoids in the estuary. This would be the period of most rapid colonization, so impacts from any burial that could occur would be minor. Also, organisms normally inhabiting muddy areas are more tolerant of high suspended solids concentrations (Peddicord et al. 1975, p. 11).

Impacts of riverine derived suspended solids from construction on phytoplankton and zooplankton could be significant for short periods following intermittent landslides. Suspended sediment concentrations in excess of 100 mg/l may cause a decrease in primary production of marine plankton and a reduction in feeding success of some calanoid copepods (Sherk et al. 1976). Highest measured suspended solids concentrations in the Blossom River are greater than 250 mg/l (VTN 1984, p. 17), and those in Wilson Arm are less than 1 to 2 mg/l (Burrell 1983). Burrell's (1983) values were not based on storm flow runoff, suggesting these values may be naturally higher. Most of the river derived sediment is deposited in the estuary and uppermost region of the fjord. Accordingly, the maximum anticipated increase in sediment loading (15 percent) is not expected to increase suspended solids concentrations to a level deleterious to phyto- and zooplankton.

Operational Phase Impacts - Sediment Runoff

During the operational phase of the project, truck activities on both the access and Tunnel Creek roads would increase sediment loading to the marine environment by 5 percent (2,800 tons) per year over natural levels (Appendix E, Section I). About 65 percent of this increase comes from the mine access road, the remaining from the Tunnel Creek road, Blossom River supplemental water supply facility access road, and other activities. Nearly all runoff would be similar in composition to natural sediment (i.e., sand size or smaller). This quantity of sediment would not cause significant impacts to marine organisms.

Operational Phase Impacts - Tailings Discharge

During tailings discharge, some zooplankton and larvae would be entrained in the mixing box at 36 m (120 ft) depth. Some of these organisms would suffer mortality after mixing, primarily from abrasion in the tailings discharge. The intake depth is below the photic zone (100 ft, 33 m) so loss of phytoplankton should not occur. Zooplankton concentrations are also highest in the photic zone above the intake. However, some important zooplankton, such as euphausiids, ichthyoplankton, and meroplankton, are found at the depth of intake and would be entrained. Although some of these organisms would suffer mortality from being entrained in the intake, the effect on the food chain is expected to be insignificant. The studies by Waldichuk and Buchanan (1980, p. iv-vii), at Island Copper, mentioned no impact on the zooplankton from entrainment in the mixing box.

The major project impacts on the marine environment from the first discharge option, direct discharge to the inner basin without the tailings pipe move, would result from marine tailings disposal. After 12 years, the present model predicts that significant tailings (greater than 10 percent; Ryan 1985, p. 13) discharged to the inner basin would begin spilling over the sill into the middle basin when the inner basin has been filled to the sill depth of 330-390 ft (100-120 m) (Ryan 1983a, p. 78). Thereafter, the middle basin would begin to fill.

Recent work (Ryan 1985) addresses the distribution of tailings in both inner and middle Boca de Quadra with continuous discharge in the inner basin. Work at the Island Copper mine on Vancouver Island suggests that a high density plume, containing high suspended sediment concentrations, exists mostly within 10 m above the bottom, with some high concentrations shallower, at a distance over 1.2 mi (2 km) from the outfall (Rescan 1983). Ryan (1985, p. 13) states that at the end of the project most of the fill area in the inner basin is below 80 m. Therefore, we will assume that the inner basin bottom would be filled to 80 m in the central area. Also, a suspended sediment density current was conservatively assumed to be 20 m deep above the bottom. As a result, all depths below 60 m in the inner basin were assumed to be impacted at some time during the life of the project.

Ryan's model indicates that after 55 years of discharge directly to the inner basin, the region from 3 km upfjord of Marten Arm to the inner basin sill would be filled from about 120 m to 240 m below surface (Ryan 1985, p. 14). If a suspended sediment plume is assumed at 20 m above the fill, the range would be from 100 to 220 m, with an average of about 160 m below surface. Therefore, burial of organisms in all areas below 160 m in this portion of the middle basin is assumed at various times during the life of the project.

Beyond the inner portion of the middle basin the bottom drops sharply (Ryan 1985, p. 14). It is assumed that the area of burial will lie below 220 m in the outer portion of the middle basin. Based on the estimated area affected, 67 percent of the inner basin and 36 percent of the middle basin bottom area would be covered by tailings discharge at the end of the project (Appendix G, Table 10-1).

The major effects of marine tailings disposal would occur as a result of burial of marine organisms, suspended sediments, and toxicants present in tailings. Each of these are discussed separately below.

<u>Marine Organism Burial From Tailings Discharge</u>

Burial impacts, including suffocation of organisms and alteration of habitats, are a function of settling rate, not just quantity of tailings. Instantaneous burial with 2 to 8 cm of Quartz Hill tailings apparently prevented nearly all natural polychaete worms from burrowing to the surface, although 33 to 89 percent were still alive after five days in the sediment under the tailings (VTN 1983m, pp. 41-44). An organism's vulnerability to smothering is influenced by its morphology, life history, and behavior, depth and duration of burial, type of sediment deposited, water temperature, and chemical conditions (Auble et al. 1984). A sedimentation depth of about 1.0 cm appears to be the no-effect level for smothering of benthic invertebrates >0.5 to 1.0 cm in size (Davies et al. 1984; Jones and Stokes 1984; Rhoads and Young 1970; Yeo and Risk 1979; Turk and Risk 1981; Rose 1973).

Unfortunately, no experiments on Quartz Hill tailings were conducted with rates less than instantaneous. Jones (1974) found no loss of biomass or density in areas of tailings sediment in Rupert Inlet of

9-18 cm total (4.5-9 cm/yr estimated from these data). He did find what appeared to be some reduction in production. He also found nearly complete mortalities of benthic organisms at 40-50 cm. Turk and Risk (1981), examining effects of natural sedimentation rates of less than 122 cm/yr, found no significant mortalities for the bivalve *Macoma*. It took 144 cm/yr to obtain 50 percent mortality of *Macoma*, but the amphipod *Corophium* had high mortalities at 23 cm/yr. It appears from these data that low or insignificant mortalities would occur with sediment rates of only 4.5 to 9 cm/yr.

Estimates of mortalities in the benthic habitats were based on the assumption that high sedimentation rates would occur in those areas receiving the bulk of the sediment (see earlier discussion of depth of impact by basin). An estimated loss of 14,560 kg/yr of economically important demersal marine species would occur with discharge directly to the inner basin (Table 4-12). This is the highest loss of any discharge option. The higher values are partly a function of the high density of commercial organisms in the relatively shallow water that would be affected in the inner basin. For example, dungeness crabs were typically 2-6 times more abundant in the upper 100 m than in the 100-200 m depth range (see Appendix G, Table 9-3). Also, spot and coonstripe shrimp, both important economic species, were more abundant in depth less than 150 m than in the deeper water that would be impacted in the middle basin. It should be emphasized that these estimates are very crude, based on many assumptions concerning fish distribution, benthic invertebrate abundance, and tailings behavior. These values should be viewed as an index number used as a means of comparison between alternatives, not absolute values. The estimation of lost biomass includes organisms buried directly and organisms lost to the area because of habitat burial. These values represent total biomass of a species or group, not just harvestable biomass. The number presented as lost kilograms represents the estimated standing stock that would have been present in the areas covered by sediment at the end of the project (i.e., maximum estimated area covered after 55 years of discharge [km^2] times estimated density [kg/km^2]). The accuracy of these standing stock values (density of organisms per area) may be questionable because they are based on maximum average otter trawl catches collected infrequently and during different seasons for each waterbody. The multiplication factor in Table 4-12 is the estimated area receiving significant settling rate times the number of years it received high rates. This factor, multiplied by the lost biomass number, represents the lost biomass of organisms during the life of the project. One of the main assumptions in using this factor is that for every year a significant sedimentation rate occurs, the estimated preproject standing stock biomass in that area will be lost and at the end of one year that area impacted will be totally recolonized. For complete assumptions and calculations used see Appendix G, Section 9.

TABLE 4-12

WORST CASE ESTIMATES OF KILOGRAMS OF IMPORTANT DEMERSAL ORGANISMS
LOST BY ACTIVE BURIAL OF HABITAT FROM SCHEDULED TAILINGS DISCHARGE

Waterbody and Option	Organisms: Dungeness Crab	Tanner Crab	Pot 2/ Shrimp	Trawl 2/ Shrimp	Walleye Pollock	Rockfish	Flatfish	Total	Multiplication Factor 1/: Option 1 Inner Basin Discharge	Option 2 Direct Middle Basin Discharge	Option 3 Middle Basin Discharge Pipe Move	Option 4 Smeaton Bay Discharge
Boca de Quadra 3/												
				Standing Stock (kg) 4/								
Inner Basin	2610	760	1310	8040	2300	100	9060	24,180	27.5	0.0	7.0	-
Middle Basin (Inner) 5/	700	360	180	1110	1380	910	500	5,140	25.5	32.5	25.5	-
Middle Basin (Outer) 5/	0	160	30	330	30	550	80	1,180	3.4	12.1	3.4	-
				Annual Losses (kg) 6/								
Option 1 Annual Average	1630	560	740	4560	1790	510	4770	14,560				
Option 2 Annual Average	410	250	110	730	820	560	310	3,190				
Option 3 Annual Average	660	270	250	1560	930	470	1390	5,530				
Smeaton Bay/Wilson Arm 7/												
				Standing Stock (kg) 4/								
Wilson Arm	1780	3250	430	6490	520	20	6140	18,630	-	-	-	18.2
Bakewell Arm	30	1070	80	3810	170	0	740	5,900	-	-	-	18.2
Smeaton Bay	1080	2800	930	6930	1130	40	5050	17,960	-	-	-	18.2
				Annual Losses (kg) 6/								
Option 4 Annual Average	960	2360	480	5700	600	20	3950	14,070				

1/ Values are derived from estimates of number of years times the proportion of area that will be significantly inundated during those years. See Appendix G, Table 9-3 for complete explanation of factor.
2/ Pandalid shrimp: Pot shrimp = spot and coonstripe shrimp; trawl shrimp = pink, sidestripe, and ocean pink shrimp.
3/ Losses in Boca de Quadra assumes complete destruction of all fish and shellfish, their habitat or both on the bottom below 60 m in the inner basin, 160 m in the middle basin (inner), and 220 m in the middle basin (outer).
4/ Values are maximum standing stock estimates. These estimates are for areas significantly inundated by tailings near the end of the 55 year discharge period. Values include all organisms by group, not just commercial size individuals (see Appendix G, Section 9 for how calculated).
5/ Middle basin (inner) is area before the basin starts into the deepest part. This area begins about 3 km upfjord from Marten Arm extending to the inner sill. Middle basin (outer) is remaining area to Kite Island sill. Marten Arm and Mink Bay are not included as no losses will occur in these bays.
6/ Annual average loss values for 55 years (i.e., option multiplication factor x lost standing stock per waterbody/55 years) (see Appendix Section 9, Tables 9-1, 9-2, and 9-3.
7/ Losses are assumed below 75 m in Wilson Arm, 90 m in Bakewell Arm, and 115 m in Smeaton Bay.

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Although an upper tailings plume may occur in areas below the depth of discharge, it is not expected to have a significant effect on burial of organisms. Work at the Island Copper Mine (Rescan 1983) indicated that a plume of fairly uniform sediment concentrations of less than 20 mg/l occurred at the level of discharge (50 m) down to the lower tailings density current (Figure 4-5). This plume was found to distribute across the width of the fjord (Bechtel 1984d). Bechtel (1984d) calculated that for Quartz Hill tailings concentrations of 20 mg/l, the deposition rate would be less than 4 cm/year in Boca de Quadra. More recent estimates vary in their prediction of tailings deposition from the side wall tailings plume. Ryan (1985, p. 28) states that, based on settling test work by Bechtel, the rate of settling on the side would be 0.5 to 7 cm/yr, while work by Kowalik (1984) suggests that rates may be as high as 20 to 180 cm per year in the inner basin if discharges were directed to the middle basin. The higher value (180 cm/yr) was considered by Ryan (1985, p. 28) to be very conservative. Although the rates by Kowalik are not directly applicable to discharge to the inner basin, they do suggest that higher settling rates could occur.

Kowalik (1984) models in general appear to be less applicable to the projected settling rates in the basins. They were only two-dimensional models; that is, they only considered plume distribution up and down not across the fjord. Also they were based on uniform concentrations across the entire bottom of the basin at the start of each model, which is therefore not totally representative for a single discharge location. They also consider distribution only during the summer season, which is the most active period of current, increasing tailings distribution relative to the annual average. Therefore, the higher values estimated from the Kowalik (1984) models appear to be unrealistically high.

As discussed earlier, sedimentation rates of 4.5 to 9 cm/year appear to have minor and probably insignificant effects on benthic organisms. Most of the model data suggest that the suspended sediment concentrations possibly occurring below 50 m would be low, resulting in low sedimentation rates and causing insignificant mortalities from burial.

Initial recolonization could be rapid, but complete recolonization could take more than a year. In VTN's recolonization studies, the number of species reached nearly the same level in Quartz Hill tailings as in natural sediments after three months in Boca de Quadra (VTN 1983m, pp. 37-38). The largest difference was in the shallowest station (95 m) where more species were present in natural sediment. Also, the predicted rates of recovery were similar. The average recovery time for tailings was 1.7 times longer than natural sediments (range 1:1 to 2.7:1). Also, growth (size) was the same for 68 percent of the polychaete species. Of the remaining species, 75 percent were larger in natural sediment.

Actual recovery may take longer than suggested in VTN's tests and species composition may differ from preoperation for several reasons. First, their conclusions were for areas adjacent to undisturbed sediment, which allowed for easy access of organisms from adjacent sediment. In the basin, under active deposition large areas would be disturbed and undisturbed areas may be few. Second, bivalves were notably absent in their recolonization experiments. Third, linear extrapolation of time to recovery may not be valid because the experiments were done over a short period, during the spring when recolonization would typically be rapid. Also, as the bottom becomes shallower from the fill, the species composition would change from deep benthic to shallow benthic organisms.

Some other fjord mine tailings disposal studies suggest that impacts would be less severe than estimated here. At the AMAX molybdenum mine in Alice Arm, B.C., the bulk of the tailings discharges remained in the central area of the discharge basin and no tailings were found beyond the sill, 8.7 mi from the outfall. Waldichuk and Buchanan (1980, p. 5), summarizing studies of mine tailings impacts on Rupert Inlet, Vancouver Island, state that the only commercial fishery that appeared to have decreased was the pot shrimp catch. However, Waldichuk and Buchanan also note (1980, p. 20) that no precise data were available on crab, prawns, salmon, and other fisheries, so a critical assessment of other commercial stocks could not be made.

Marine tailings from other mines have also been found to be recolonized (Waldichuk and Buchanan 1980, p. V; Levings 1975; Jones and Ellis 1976). Pelletier (1977, p. 29) found that areas heavily impacted from tailings during early years of operation at Island Copper have since returned to previous abundance of benthic organisms.

Only minor food chain impacts may occur from burial of the deep benthic area. Although food and energy flow is mostly from the upper water column to the deep benthic area, some does flow from the deep benthic to near surface (VTN 1983h, p. 132). With the loss of spawning demersal fish such as flatfish, reduction in eggs and larvae would occur in the surface water. At times fish eggs and larvae are a major food for herring and juvenile salmon in these fjords (VTN 1982e, p. 70, 1982i, p. 60).

Although some of these eggs originate from deep benthic areas, many of the eggs and larvae originate outside of the fjord. The two most abundant larvae in the fjords were herring and walleye pollock, and both have major spawning areas outside of the fjords (VTN 1982h, p. 33, 1982m, p. 49). Although some impact may occur from loss of eggs from the deep benthic area, effects should be insignificant.

Suspended Tailings in the Marine Environment

Some tailings sediment would become suspended in the water column. Infrequent large slumping events, particularly in the inner basin, may bring some sediment near or into the upper water column. However, it appears that tailings would rarely reach the uppermost water column or

photic zone (100 ft [33 m]) but will be above 100 m DRRP (see Physical Oceanography Section 4.1.6.2). The modeling effort by Kowalik (1984, p. 180) also indicates that tailings will not pass 30 m and most often will be below 60 m. If the typical Rupert Inlet near-bottom tailings plume concentration (200 to 600 mg/l, Ryan 1985, p. 15) is assumed for the Kowalik model, the tailings concentration just below the photic zone will be near background (less than 2 mg/l). Further, tailings concentrations at their shallowest depth in the Kowalik (1984, p. 118) model will be 2 to 6, 20 to 60, and 100 to 300 mg/l at about 35, 50, and 70 m depths, respectively. As discussed previously, these models may indicate higher values than would be expected over large areas or time periods.

In Alice Arm, suspended material has not been observed above depths of 200 ft (65 m) and an increase in turbidity was not observed in the photic zone. Concentrations of suspended sediments in a mid-depth cloud of tailings fines (60-100 m) were about 15 mg/l at a distance of 0.6 mi (1 km). Rescan (1983) reported that, during discharge of 60,000 tons per day in Rupert Inlet, suspended sediment concentrations within 0.6-1.2 mi (1 km-2 km) of the discharge from the discharge depth of 165 ft (50 m) to near the bottom were fairly constant at 10-30 mg/l. A reasonable assumption is that similar levels and distribution would occur at Quartz Hill. Thus, if tailings do not reach the upper water column, effects on the seaward migration of anadromous fish in the fjord would be insignificant. This is because more than 90 percent of the seaward migrating juvenile salmon are typically in the upper 30 ft of the water column (Stober and Salo 1973, p. 50).

Phytoplankton production could be affected by suspended sediment concentrations in the photic zone, but increased suspended sediment levels should occur very infrequently and only during slumping events causing a localized reduction in production. Sherk et al. (1976) found that it required concentrations of 100-500 mg/l to significantly reduce primary production for marine phytoplankton, although some reduction was observed at concentrations of 50-100 mg/l. Sullivan (1979, p. IX) studying Rupert Inlet stated the only measurable reduction in primary production occurred in the vicinity of waste rock discharge and not tailings discharge.

Major zooplankton concentrations are most often in the photic zone (see Section 3.2.2) and should not be significantly impacted. However, some important diurnal migrating zooplankton such as euphausiids and some ichthyoplankton or meroplankton spend a significant part of the day below 50 m. Euphausiid adults particularly have been identified as major food items for larger herring and walleye pollock (VTN 1982i, pp. 59-60, 1982h, p. 65). These organisms, particularly in the inner basin, may encounter higher concentrations. Studies on a calanoid copepod found that no significant reduction in feeding occurred at levels lower than 250 mg/l. However, another zooplankton that was not a selective feeder encountered reduction in feeding at 100 mg/l (Sherk et al. 1976). Often diurnal migrating zooplankton do their feeding in the upper water column. Still, the levels expected in the water column should only be in the range of 10 to 30 mg/l based on Rupert Inlet studies, or 20 to 60 mg/l at 50 m, based on the Kowalik (1984) model,

so impacts are not expected to be significant except for small localized areas from large slumping events. Inner basin important migratory zooplankton found between 50 and 100 m deep are more likely to encounter high suspended sediment concentrations than in the middle basin because a dense tailings plume will be within that depth range with direct inner basin discharge. Pelletier (1977, pp. 24 and 27), summarizing the results of phytoplankton and zooplankton studies in Rupert Inlet near Island Copper mine, states that no measurable negative impacts have occurred in phytoplankton or zooplankton abundance since the mine began discharging.

Biological transport of a significant amount of tailings into the surface water is unlikely. Only five mesopelagic zooplankton species that reside in potential areas of suspended tailings concentration vertically migrate to the surface waters (<25 m deep). The most abundant of these are Calanus spp. and Metridia pacifica. Their combined average abundance in Boca de Quadra was about $100/m^3$ (VTN 1982h, pp. 41-42). Euphausiid adults, which are also migratory, are usually less than $1/m^3$ (VTN 1982g, pp. 41-42). Any tailings that may possibly be transported upward by attachment to their bodies should be minor. This conclusion is reached because of the large volume of water relative to the low density of organisms.

Because of herring overwintering distribution and behavior, their habitat may be impacted by tailings discharge to the inner basin. Impacts to herring habitat may result from actual burial of bottom or depth preference areas or encounter of herring with the tailings plume. Whether these habitat impacts would cause a reduction in herring survival and abundance cannot be determined. Some Alaskan stocks of overwintering herring are found below 50 m (Carlson 1980, p. 71). Overwintering Alaska Pacific herring can occur to 140 m, but typically the one-year-old herring are shallower (Blankenbeckler 1985). They often descend to near bottom during the day and migrate to near surface at night (Blankenbeckler 1985). A study of Atlantic herring stocks found the depth preference of herring is often light-intensity related; that is, they select a specific level of light intensity, which results in daily vertical migration (Parrish and Saville 1965, p. 369). The only winter herring survey conducted in Boca de Quadra (in February 1980) found mostly one-year-old herring abundant in the inner basin, although some were also present in the middle basin. An October fish survey by VTN (1982, p. 50) indicated concentration of underyearling and one-year-old herring present in Mink and Vixen bays, possibly overwintering there. As juveniles, Atlantic herring were found during bioassay studies to avoid areas of 9 to 12 mg/l suspended solids (Messieh et al. 1981, p. 6; Johnson and Wildish 1981, p. 308). No comparable literature on behavior of Pacific herring were located, and Pacific herring are known to be found in some turbid water areas such as the Fraser River delta (Geen 1984).

Based on possible behavior and distribution of herring, we assessed potential herring habitat impacts using three different methods. Depending on which assumptions and models are used, conclusions about potential impacts to herring habitats vary (Table 4-13). All three

TABLE 4-13

POTENTIAL HERRING HABITAT AFFECTED BY TAILINGS DISCHARGE DEPENDING ON TAILINGS DISCHARGE OPTIONS AND VARIED ASSUMPTIONS OF EFFECTS

Methods	Inner Basin	Inner Move Middle Basin	Middle Basin	Smeaton Bay/ Wilson Arm
Bottom Area[a/]	2.3 km^2	2.3 km^2	0.2 km^2	3.2 km^2
Volume Covered[b/]	0.19 km^3	0.19 km^3	0.03 km^3	0.18 km^3
Suspended Tailings[c/]	1.27 km^3/yr	1.20 km^3/yr	1.58 km^3/yr	0.56 km^3/yr

a/ Area (km^2) affected assumed to equal the bottom surface area less than 140 m deep covered by tailings at the project end (55 years).

b/ Volume (km^3) affected assumed to equal water volume less than 140 m deep buried by tailings at project end (55 years).

c/ Volume affected during discharge per year (km^3/yr) assumed to equal water volume less than 140 m deep with suspended tailings of greater than 20 to 60 mg/l based on models of Kowalik (1984) and Kowalik and Findikakis (1985).

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methods assume that Pacific herring may use marine habitat down to 140 m deep. The first (bottom area) method assesses the habitat impact by assuming bottom area (km^2) less than 140 m deep covered by tailings at the end of the project will be the impacted herring habitat. Using this method, most (about 90 percent) of the impacts to herring habitat (2.3 km^2) occur in the inner basin. The main assumption for this impact assessment is that herring may orient to a specific bottom depth by region and if depth is changed, habitat will be lost (Table 4-13). (See Appendix G for complete description.)

The second (volume covered) method is the same as the first except it assumes that the volume (km^3) less than 140 m deep covered by tailings at the end of the project will be the impacted habitat. Again, most impacts to herring habitat (0.19 km^3) occur in the inner basin. The main assumption for this impact assessment method is that herring may be orienting to a specific depth based on light intensity and if the basins are filled to a depth less than 140 m they may not be able to descend to their preferred light level depth (Table 4-13).

The third (tailings plume) method assumes herring will avoid, and therefore lose, habitat in areas of tailings concentration in excess of 20-60 mg/l at depths less than 140 m (Table 4-13). Unlike the previous two methods, this method estimates that the majority of impacted herring habitat will occur in the middle basin (about 80 percent) even with an inner basin discharge (Table 4-13).

The models of Kowalik (1984) indicate for inner basin discharge that suspended sediment between 20 and 60 mg/l will occur in the region of 60-80 m deep over a large part of the length of the inner basin. For a middle basin discharge the depth range would also be 60-100 m (Kowalik 1984, pp. 106 and 115) at times over a majority of the middle and inner basin length. Also, as the inner basin fills, the model assumed the plume from an inner basin discharge will be similar to that of a direct middle basin discharge (Kowalik 1984, p. 147). The distribution of suspended tailings is based on the models of Kowalik (1984), which estimates linear distribution of percent of near-bottom tailings plume concentration at the end of summer. There are problems with using these models to estimate tailings density concentrations in the water column in the winter. These models only estimated end of the summer concentration and distribution up and down, not area of the fjord. Also the original tailings plume in the model was distributed along the whole length of the bottom which could differ greatly from what the distribution would be like from a single point discharge.

The results of these three methods demonstrate how conclusions of impacts to herring habitat will vary depending on what assumptions are made. Also, alteration of herring habitat may not result in any direct loss of herring. Herring may alter their distribution in response to change in bottom contour or tailings plume and still undergo no related reduction in abundance. Currently the lack of more specific information about distribution, abundance, and behavior of herring within Boca de Quadra makes more definite conclusions about impacts from tailings discharge unreasonable.

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Although herring are common prey organisms for some marine organisms (Hart 1973, pp. 96-100), they appear to be of minor importance as a fish prey organism in Boca de Quadra. Because the only major herring predator found in Boca de Quadra was dogfish (VTN 1983h, pp. 148-157), losses of herring would have no significant food chain effects. It is possible that VTN sampling may have missed some predators of herring (e.g., adult salmon, eagles), in which case significant effects may occur to other predator animals if herring losses were large.

Tailings in the upper water column could also impact herring spawning success in inner Boca de Quadra. No reduction in hatching success has been found at suspended sediment concentrations of 7,000 mg/l for Atlantic herring, although a sediment covering 1 cm deep caused complete mortality, and even a light covering of sediment caused some mortality (Messieh et al. 1981, p. 4).

Abundance, location, and depth of spawning are not known for inner Boca de Quadra. However, based on larval density, little spawning probably occurs in the area. Spawning at the mouth of Kah Shakes has been observed down to 36 ft deep (Blankenbeckler and Larson 1982a, p. 7), and it is expected that most spawning would occur above this depth. Current estimates indicate tailings would be that shallow only from large slumping events or tailings spills. If these events were to deposit tailings in the shallow near-surface area during spawning and egg development (late March-April), some larval herring losses would occur. The apparent low abundance of adult herring spawning within the inner basin and expected low frequency of tailings in surface waters suggest insignificant impacts to commercial harvest of herring or the food chain.

Another concern is that tailings may impact herring spawning areas at Kah Shakes. A small quantity of 10 μ (micron) diameter fine particulates generally below detection could move over the Kite Island sill according to Ryan (1983a) (see physical oceanography impacts, Section 4.1.6.2). The fjord circulation models (Kowalik 1984) also indicate that some tailings at a concentration of 2 to 6 mg/l may pass over the middle basin sill near Kite Island at about 60 m depth. This quantity would not affect spawning of herring because it would be below depth of herring spawning, it would equal a settling rate of less than 1 cm per year (Bechtel 1984f), and most would never reach Kah Shakes.

Toxicity and Bioaccumulation of Tailings

Two key toxicological issues arising from the marine disposal of mine tailings include the potential (acute and chronic) toxicity of both liquid and solid phases of the discharges and the bioaccumulation of heavy metals and/or the organic milling reagents contained in the tailings. Both issues are assessed in detail in Appendix G, Section 12 with regard to EPA's Ocean Discharge Criteria.

Information from various toxicological tests (EVS 1984a, 1984b) suggests that tailings from the proposed Quartz Hill facility would possess a low acute toxicity to marine organisms that can avoid

the tailings plume. Metals in the tailings do not appear to be bioaccumulated to the extent known to be inimical to other marine organisms, wildlife, or public health. However, only a provisional assessment of the hazard from the tailings can be made at this time because of important gaps in information, especially concerning the organic milling reagents. For example, there was not enough information provided by EVS (1984a, 1984b) to determine whether the tailings, including the organic milling reagent component, were broadly representative of the tailings that would be discharged at Quartz Hill. Additional information concerning acute toxicity, chronic toxicity (including sublethal effects), bioaccumulation potential, and persistence of these chemicals in various parts (e.g., in water and in sediments) of the aquatic environment will be obtained and evaluated prior to issuance of the NPDES permit and through monitoring during project operation.1/

Toxicological and chemical fate data for the milling reagent M-502, a quaternary ammonium compound, exemplify the types of data gaps being alluded to. The accessible toxicological data base pertains only to acute (less than or equal to 48-hour exposure duration) toxicity tests of other types of quaternary ammonium compounds conducted with several species of freshwater fish (see Appendix G, Section 12). There is no assurance these compounds possess acute toxicities comparable to M-502. Data on M-502's bioaccumulation potential, persistence in the environment, and other toxicological and chemical fate properties are needed to assess its hazard to aquatic life.

With regard to the bioavailability of metals in sediments, much attention has been focused on copper. It is the metal of greatest concern with regard to toxicity to marine organisms, because copper may assume many forms in aquatic environments. If most of the copper occurring in mine tailings were bioavailable, then aquatic toxicity could occur. This, however, is not expected to be the case. Appendix G discusses this issue in greater detail.

Acute Toxicity

Information regarding the potential toxicity of milling reagents and metals is contained in Section 12 of Appendix G. Table 12-1 contains information on toxicity of organic reagents to aquatic organisms. Table 12-2 lists concentrations of metals which have been demonstrated to be acutely toxic.

1/ It should be possible to perform the first phase of the hazard assessment (ASTM 1985a, p. 618) with the following information:

- o Acute toxicity - 96-hr LC50 for a sensitive fish or invertebrate (does not need to be indigenous).
- o Bioaccumulation Potential - octanol-water partition coefficient.
- o Persistence - half-life in water containing a diverse microbial flora.

Results of bioassays conducted by EVS (1984a, 1984b) suggest that Quartz Hill mine tailings have a relatively low acute and chronic toxicity to zooplankton and larvae of marine organisms. However, these conclusions are provisional because the test results possessed several flaws in methodology that undermined the validity of the results. Points of concern about the methods include control mortality that exceeded usual ASTM/EPA criteria for test acceptability; test concentrations that were allowed to vary over time; and major differences between nominal and measured concentrations. In other words, it was difficult to determine exactly what concentrations the test animals were exposed to, and determine whether some of the test animals were healthy or stressed. Previous studies conducted on tailings from the Kitsault mine are considered more representative of actual exposure levels than the studies reported for Quartz Hill tailings because suspended solids concentrations remained constant throughout the study period. It appears that the test concentrations of Kitsault mine tailings may more accurately represent concentrations that are likely to be encountered in the field.

Concern remains over effects of long-term, low concentration (chronic) exposures of marine life to suspended tailings in the upper mesopelagic zones of the receiving fjord. Long-term exposure to low concentrations cannot be dismissed as a potential impact, particularly with the lack of chronic toxicity data currently available.

It is likely that one of the greatest risks to biota exposed to Quartz Hill tailings will be physical in nature. Tailings suspended in the water column can impact aquatic life by abrading and/or clogging respiratory and feeding mechanisms and by causing them to avoid feeding areas containing suspended solids above threshold avoidance levels. Mobile predators that feed visually may be forced to leave the area due to reduced visibility caused by the suspended solids. The tailings contain high concentrations of suspended solids ranging between 25,000 and 225,000 mg/l (assuming a saltwater dilution of 1:1 to 1:4 for tailings with 45 percent solids, see Section 2.2.5) between the outfall and 100 m from the outfall. Lower concentrations of suspended particulates have been known to cause problems with juvenile fish and filter feeding organisms. For example, juvenile chum salmon can avoid suspended solids concentrations of up to 190 mg/l, but do not survive concentrations of 16,000 to 55,000 mg/l (Campbell 1979; Smith 1979). Concentrations of suspended solids expected in the mixing zone of Boca de Quadra are within a range known to be lethal to some species of marine life (Appendix G, Table 12-2). Planktonic fish and invertebrates are most vulnerable because of their limited ability to avoid the plume. It is reasonable to expect mobile species like fish to avoid those sectors of the plume where there are high suspended solids concentrations. Macroinvertebrates are generally less mobile, however, and may not be able to avoid a plume containing high concentrations of suspended solids. Earlier in Chapter 4.0 the effects of sediment rates and depths on immobile benthic invertebrates were discussed. Significant adverse effects would be expected at rates exceeding 4.5-9 cm/yr and at instantaneous burial with greater than 1.0 cm of sediment.

Bioaccumulation and Biomagnification

Bioaccumulation of some of the heavy metals expected to occur in the Quartz Hill tailings has been demonstrated in several studies of prototype Quartz Hill tailings and tailings from AMAX's molybdenum mine (AMAX 1983) and Island Copper's mine on Vancouver Island (Goyette and Nelson 1977). In every case, however, the level of bioaccumulation observed in tests of aquatic life have been observed to be below levels believed to be hazardous to aquatic life and human health, based on a review of EPA's water quality criteria for several heavy metals (EPA 1985a, 1980b, 1980c, 1980d, 1980f, 1980g, 1980j). The bioaccumulation potential of metals in samples of the types of tailings expected to be generated by the Quartz Hill facility has been investigated by EVS (1984a, 1984b). In general, the studies demonstrated negligible bioaccumulation of cadmium, copper, iron, lead, manganese, and molybdenum after 1-4 months in tissues of a deposit-feeding clam, a filter-feeding clam, a flatfish, and a crab. These findings are somewhat surprising because several of these metals are bioaccumulated significantly in some species of marine life. The results contrast somewhat with those observed during the biomonitoring program at AMAX of Canada's Kitsault, B.C., mine. Some marine clams (in particular *Yoldia thracialformis*) had elevated copper, cadmium, lead, and zinc in their tissues. The highest concentrations of metals found in tissue samples from three bivalve species, *Mytilus edulis*, *Clinocardium* spp., and *Yoldia thracialformis*, collected at stations around the AMAX molybdenum mine, though elevated, are within expected and allowable ranges (AMAX 1983). Similarly, two bivalves collected in waters receiving tailings from the Island Copper mine had elevated concentrations of copper in their tissues. Concentrations ranged from 66 to 305 μg/g dry weight in *Macoma iris* and from 5 to 150 μg/g dry weight in *Mytilus edulis* (Goyette and Nelson 1977). In light of the general conclusion for the proposed tailings that dietary accumulation of fish and shellfish is expected to be minimal for the proposed mine, it is not expected that biomagnification would be a significant problem for these organisms. In fact, none of the metals have been found to accumulate sufficiently to warrant placement of maximum acceptable limits on fish and shellfish (EPA 1980b, 1980c, 1980d, 1980f, 1980g, 1980j).

The hazard associated with bioaccumulation of the organic milling reagents in the tailings remains to be assessed in order to confirm findings made in laboratory and field studies elsewhere and to judge the hazards associated with residues of the chemicals in aquatic and terrestrial food chains, including man.

Many organic chemicals possessing some degree of solubility in fats are known to bioaccumulate in aquatic food chains. Most chemicals--prominent exceptions being polychlorinated biphenyls, DDT (and analogous organochlorine hydrocarbons), and methyl mercury--do not appear to biomagnify (Macek et al. 1979; Thomann 1981; Mearns and Young 1983). This is principally because aquatic organisms have the capacity to metabolize and excrete the chemicals.

The remaining question concerns whether measured body burdens of the chemicals present a hazard to the organisms possessing them, to predators, or to human health. Available evidence indicates that most metals do not accumulate to sufficiently high levels in aquatic organisms to pose a hazard to man. Because there is virtually no concrete information to the contrary, the assumption is made that other predators of aquatic organisms--whether fish, invertebrates, mammals, or birds--will not be affected if people are unaffected. Criteria are unavailable for manganese and molybdenum because the available literature indicates they have both low aquatic toxicity and a low probability of accumulation in aquatic and terrestrial food chains.

These concepts are borne out by the fact that most of the EPA water quality criteria for metals, which are intended to protect people from the hazards associated with consumption of contaminated aquatic organisms, are higher than the criteria set to prevent metal toxicity. The only exceptions are arsenic, selenium, and methyl mercury, for which risks of cancer, selenosis, and neuropathic disorders have been associated with certain water concentrations. Many of these concepts are embodied in Table 12-2 in Appendix G, which contrasts all the applicable EPA water quality criteria concerning the protection of aquatic life from toxicity with criteria protecting human health from consumption of contaminated organisms. Appendix G, Section 12 focuses on findings of various bioaccumulation assessments performed to evaluate the hazards associated with tailings from the Quartz Hill facility. The results of these assessments agreed with the general toxicological literature concerning chemical bioaccumulation and biomagnification.

In summary, the existing information suggests that tailings from the proposed Quartz Hill facility would possess a low acute toxicity to marine organisms larger than plankton. Moreover, metals in the tailings do not appear to be bioaccumulated to the extent known to be inimical to other marine organisms, wildlife, and public health. There are, however, some important gaps in information that should be addressed as part of an NPDES permit. More definitive information is needed concerning the chronic toxicity of the tailings, particularly effects on reproduction, and on the bioaccumulation potential of the organic milling reagents.

Oil and Chemical Spills

In addition to impacts from the disposal of tailings, impacts to the marine environment may also occur as a result of oil and chemical spills. Spills of chemicals, including explosives (e.g., ammonium nitrate) and milling reagents (e.g., lime) are expected to occur rarely. The potential for damage to marine life varies from insignificant to significant depending upon the chemical spilled, the amount, and the location. Available information on probability of spills and expected effects on marine life from a major spill are described in a worst case analysis in Appendix G, Section 15.

The potential for oil spills is a valid concern because large volumes of diesel and other fuel oils are scheduled for use in the mill, power plant, mining equipment, etc. A discussion of oil spill probability and potential effects in marine waters is presented in Appendix G, Table 11. Spills during off-loading while tankers are at berth are more probable than oil spills occurring in-transit. Small spills of 315 gal or less might occur once every 116 years while tankers are at berth, but only once in 3,375 years while they are in-transit. Larger spills of 1,575 gal or more would occur rarely--only once in more than 2,000 years while at berth and once in more than 20,000 years in-transit. These spill estimates, based on spill risk analyses for Puget Sound, Washington, suggest that Wilson Arm/Smeaton Bay would not likely receive a large oil spill during the 55-year lifetime of the Quartz Hill project. For smaller and remotely probable spills of 1,000 gal or less, the region at greatest risk is upfjord in Wilson Arm and the Wilson River tidal flat. Oil tankers would be moored at a marine terminal in this vicinity for off-loading. Spills at this site could be swept by wind into the tidal flat where salmon smolt feed during outmigration. In such an event, if oil spills were large enough, significant numbers of juvenile salmonids could be lost. The probability and potential effects from a pipeline rupture is small, only once in more than 1,800 years. A pipeline carries oil from the marine terminal up Tunnel Creek to the power plant. Its improbable failure and potential biological damage is discussed in Appendix G, Section 13.

Impacts may also occur if a tailings pipeline break were to occur. Probability of a spill is expected to be very low (see Appendix G, Section 16). With the required spill containment measures, the extent of a spill is also expected to be small. The major area of impact is estimated to be a 1 hectare area mainly of nearshore habitat near the point of discharge in the middle portion of inner Boca de Quadra (see Appendix G, Section 16 for complete description of impacts). This type of spill is expected to smother nonmotile benthic organisms in a small local area. If the spill occurred during April to June, feeding of juvenile salmon along the shore could be adversely impacted. The burying of nearshore salmon food organisms such as harpacticoids and chironomids would be the major source of impact. Direct mortalities to juvenile salmon and other motile organisms from high suspended sediment concentrations are not expected to occur as concentrations would be too low and short term (<12 hours). Some temporary local reduction in primary production and feeding of zooplankton would occur. Other than impacts on feeding juvenile salmon, a spill would have minor and insignificant effects.

Another potential source of tailings into the surface water (less than 30 m) may be from freshwater flush of the tailings line. The frequency and quantity of this happening would result in only local short-term impacts. U.S. Borax (1985c) estimates that flushing would not occur more than once every few years, and would only occur from a malfunction of certain equipment. Bechtel (1984a) conducted modeling of potential upward movement of a freshwater plume if released in various areas of

Boca de Quadra. It is expected that flushing would only occur long enough to clear the tailings line of sediment, so the quantity of sediment would be equal to the tailings line volume at a maximum. They found the only time the plume would penetrate the photic zone would be during winter and early spring (January through April, Bechtel 1984, p. 44-45). During winter and early spring, few juvenile salmon would be present in the inner basin waters, as this period precedes most of their outmigration from the Keta River. Some local phytoplankton production and possible zooplankton feeding would be reduced. The duration should be short term and should not have an impact on higher organisms. Because of the low frequency and probable small quantities of tailings in the plume and time of plume occurrence, significant impacts should not occur.

Marine Fish and Shellfish Harvest

Tailings discharge may cause impacts to local sport or commercial harvest of demersal fish, crabs, and shrimp. The extent and magnitude of harvest lost cannot be predicted, but organisms that reside in the deeper area would probably be most affected. These would include tanner crab and trawl shrimp (pink and sidestripe). Lesser impacts would occur to organisms in shallower depths, including spot shrimp, which appear to be more abundant in less than 150 m of water, and dungeness crab, which had their higher abundance in depths less than 50 m. Impacts at these depths would occur mostly to the inner basin. Harvest of demersal fish and trawl shrimp in the fjord appears to be low, so impacts should be minimal, although potential future harvests may be affected. Tanner crab harvest in the Ketchikan region of southeast Alaska is very limited, so loss of commercial and sport harvest would be small. Also, studies at Rupert Inlet for Island Copper appeared to find no reduction in harvest of commercial species of shellfish, crab, and fish, with the possible exception of shrimp (Waldichuk and Buchanan 1980). Their studies were not designed to estimate losses of harvestable fish and shellfish, so some losses could have occurred that were not detected.

Impacts to some fish and invertebrate populations may occur as a result of increased sport harvests by mine personnel. However, because the operation of the mine calls for a commute option, with employees leaving the site as soon as their work shift is over (seven days on and seven days off), an increased sport harvest of crab, shrimp, or bottom fish during operation would be minimal. Additionally, during operation, all employees would be housed within the Wilson Arm area so the limited sport fishing pressure would be centered in that area. No increase in fishing activities would be expected in Boca de Quadra, as the only activity in that area concerns maintenance of the tailings outfall pipeline.

Increased boat activity should also not interfere significantly with existing harvests of marine fish and shellfish. Boat travel for transport would include two commute boat trips a day, five days a week, between the wharf and Ketchikan. Additional boat traffic from oil tankers and supply ships would occur about every three weeks.

The large size of these bays would allow several boats to pass uninhibited by other boat activity. The major herring roe fishery off Kah Shakes would have intensive gill net activity during a brief period in March and April. Increased boat traffic would occur up Boca de Quadra for the 1-1/2 to 2 year period during tunnel construction to maintain the 50 person camp. Transport vessels would have to be cautious during the fishery to minimize danger and interference with the fishing but should not have a significant effect.

Post-Operation Phase Impacts

Upon closure of the project, some remaining impacts would occur after designated reclamation activities were completed. Roads, tunnel areas, wharf, and other facilities areas should contribute minor quantities of sediment runoff after reseeding, resulting in insignificant impacts in the marine environments of Wilson Arm/Smeaton Bay and Boca de Quadra. Residual impacts to the marine environment of Boca de Quadra from tailings disposal may occur indefinitely, but should be greatly reduced within 10 years after shutdown. Some natural movement of bottom sediment after deposition has been observed in Boca de Quadra, particularly the inner basin. The shallow instability of sediments apparently results in slumping, but the exact redistribution of sediment is not clear (Burrell 1983). It is possible that this activity could keep part of the tailings on the surface sediment and in the water column.

The present natural net sedimentation rate in Boca de Quadra is between 0.9 and 1.0 cm per year (Burrell 1983, Appendix 2, p. 10). If these rates were to occur in 10 years, 9 to 10 cm of natural sediment would accumulate over the tailings if sediment resuspension did not occur. Since most benthic organisms occur in the shallow (VTN 1983h, p. 156), oxygenated sediment layers, most of the areas of the two basins would be near "normal" in sediment composition after a few years.

Even without rapid return to natural sediment composition, recolonization may be rapid, although complete recolonization may take more than one year (VTN 1983m, pp. 36-37). Delayed slumping may result in much of the area being covered with tailings after discharge has stopped, but Pelletier (1977, p. 29) states that after a two month shutdown period areas that had been obliterated by tailings discharge in Rupert Inlet were recolonized. But he did not state to what degree (percent of former population) recolonization had occurred.

After recolonization, the benthic community that develops would be different from the one prior to tailings discharge. The model by Ryan (1985, p. 13) predicts most sediment should be below 365 ft (80 m) in the inner basin and 490 ft (150 m) in the middle basin by the end of the project. Some important organisms inhabit areas below these depths (e.g., pink and sidestripe shrimp, tanner crab) but most are more abundant in the upper 490 ft (150 m). In fact, a shallower basin may improve overall basin production. Some net loss of deep water organism production, such as pink shrimp, would occur in Boca de Quadra, but some net gain in production may occur with shallow water organisms, such as dungeness crabs.

The second discharge option calls for the tailings discharge line to be moved after an unspecified period to the middle basin. All facilities and potential impacts are the same as the first option except as discussed below. This option calls for the construction of a pressurized pipe from the inner basin discharge point along the subtidal fjord wall 4.1 mi (6.8 km) to this new discharge point. One option would consist of two 24-in. pipes attached to concrete slabs for ballast and suspended by cables every 20-25 ft anchored above upper tide level. Installation of these lines would initially disturb an area below low water (-15 ft MLLW). The area would be about double the width of the pipe area, about 8 ft (2.4 m) wide, along the 4.1 mi (6.8 km) covering about 4.0 ac of nearshore habitat. This is important feeding area for juvenile herring and possibly juvenile salmon. Although salmon abundance was not measured near shore this far down the fjord, they appeared to decrease in abundance toward the outer edge of the study area, which was only about 0.5 mi (0.8 km) from the estuary tideflats. The abundance of salmon in the potentially affected areas is not known, but generally as salmon become larger they move offshore and rely more on pelagic food. Some feeding of salmon and herring would be disrupted in this area during construction. The area that would be disrupted would be prime depth for salmon, which typically stay in the upper surface water as juveniles (Stober and Salo 1973, pp. 50 and 51). This disruption of feeding may be significant the first year of construction if it occurs during the period of peak juvenile salmon abundance (March-May) (VTN 1982e, p. 53). The impact would generally lessen further downfjord as these fish would probably be farther offshore and feeding primarily on pelagic food organisms.

The concrete slabs would be similar to the rock walls of the fjord, and after installation, recolonization would result in typical benthic organism composition for this region. Periodic disturbance would occur every 4 months to 3 years when pipes were rotated or replaced. The timing of rotation or replacement will be determined by monitoring pipe wear, probably with an external density monitor. Effects at this time would be less than during construction, because the concrete slabs would not need replacing.

Another tailings pipeline installation method is for them to be placed directly on the bottom of the fjord. The pipes would be placed 30 ft out from, and parallel to, the intersection of the tailings with the natural contour of the fjord (U.S. Borax 1985d). The area disturbed and frequency of disturbance are assumed to be the same as the previous option. With this method, disturbance to the photic zone and area of salmon migration and feeding would be reduced.

The operational impacts differ from those described for the first discharge option mainly in the length of time impacts would occur to the inner basin. For the purpose of impact assessment, it was assumed that the tailings line would be moved after 14 years, although it could be moved at any time if necessary. With this subalternative, the area

impacted in the inner basin remains about the same (67 percent), but the duration of impact would be reduced from 55 to 14 years. The main effect would be to reduce impacts on demersal organisms in the inner basin. Impacts to the middle basin would remain about the same as the first option because the inner basin had little storage left after 14 years, so the same amount of tailings would enter the middle basin. The estimated losses from this option of commercially important and demersal fish and shellfish is a total of 5,530 kg/yr (Table 4-12). Potential impacts to pelagic fish in the inner basin would be reduced, but some may still occur because a water column suspended sediment plume would still be present in the inner basin from a middle basin discharge (Kowalik 1984). Also, habitat alterations are about the same as the first discharge option, creating a much shallower inner basin than currently exists and leaving the middle basin relatively deep. Estimated impacts to herring habitat based on the three methods discussed with the first tailings discharge option are the same (Table 4-13). Because of the lack of specific information on behavior and density of herring, actual loss of herring, if any, cannot be estimated.

4.2.2.3 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra Middle Basin and Commute Option

This alternative has discharge of tailings directly to the middle basin. Impacts differ from those of direct inner basin discharge described in Section 4.2.2.2 as discussed below.

The estimated average loss of commercially important benthic species is 3,190 kg/yr, lowest of any of the marine discharge alternatives (Table 4-12). As with previous loss estimates, these numbers should be considered an index number because of the many assumptions required for these calculations (Appendix G, Section 9). Because most tailings discharge would go to the middle basin, no significant impacts would occur to the inner basin organisms either from direct tailings discharge or from pipeline breaks.

The inner basin shallow water (less than 100 m) habitat would be mostly unaffected. An important commercial species, dungeness crab, which are most abundant in the region less than 100 m deep, would be affected less. Also, spot and coonstripe shrimp, which were found in shrimp pots to be most abundant in the region less than 150 m deep, would be affected less because most impacts in the middle basin would be below this depth. The percent of middle basin area impacted would be slightly higher than that estimated in Section 4.2.2.2 (36 percent; Appendix G, Table 10-1), but the impacts mainly are the duration of active fill (55 compared to 41 years) and increased impacts to the deeper part of the middle basin toward Kite Island where most of the additional fill would go. Most burial of organisms as discussed in Section 4.2.2.2 would occur in the middle basin only.

An upper suspended tailings plume may occur in the middle and possibly inner basin water column. The effect of this plume and depths of occurrence in the middle basin is presented in Section 4.2.2.2.

Generally, the plume would be at a deeper depth because of the deeper basin than in the inner basin discharge. Impacts from this plume are expected to be insignificant except possibly to herring.

Some water column suspended sediment may still be present in the inner basin from discharge directly to the middle basin (Kowalik 1984). This water column sediment in both basins may still have an effect on overwintering herring. As discussed in Section 4.2.2.2, three methods were used to estimate potential impacts to herring habitat from tailings discharge. Based on the two methods that assumed impacts to herring habitat from burial of area less than 140 m deep, almost no habitat would be impacted from direct discharge to the middle basin (Table 4-13). However, based on the third method, which assumed herring will avoid suspended sediment in concentrations in excess of 20-60 mg/l in the area less than 140 m deep, the largest volume of herring habitat impacted of any of the marine discharge options would occur with direct discharge to the middle basin. The estimated areas of herring habitat impacted with this method are mostly (about 90 percent) in the middle basin and the remainder in the inner basin. The inner basin area affected is from the tailings plume that would still enter the inner basin from a middle basin discharge. However, as stated in Section 4.2.2.2, this third method may have several problems in accurately estimating areas of suspended sediment concentration. Also, the avoidance behavior of Pacific herring to these concentrations has not been confirmed. It is possible that herring would alter their distribution relative to the tailings plume with no direct loss of herring. More definite conclusions about impacts to herring from tailings discharge are not reasonable because of the lack of more specific information about abundance, distribution, and behavior of herring within Boca de Quadra.

Also, some settling of tailings on the bottom of the inner basin would still occur with discharge to the middle basin. Ryan (1985, p. 17) reports the settling rate to be between 20 and 180 cm/yr, with the upper bound being very conservative. The EPA (1985, p. 72) analysis of impacts for the ODCE suggested settling rates from direct middle basin discharge would most probably be in the range of 4 to 15 cm/yr in the inner basin. The total area covered is unknown but would be greatly reduced relative to direct inner basin discharge. With 55 years of discharge (compared to an estimated 41 years), greater impacts would occur to middle basin organisms (Table 4-12). Food chain effects for the middle basin would be the same as those discussed for that basin in Section 4.2.2.2. Slumping events would be unlikely to bring suspended solids into the surface water (see Section 4.2.2.2). Therefore, effects on primary production would not occur. Major zooplankton population would not be affected as most are in the surface waters (less than 30 m). Also, migratory zooplankton found below 30 m should not be affected because most of the high concentration of suspended solids would be near the bottom in depths greater than 120 m. Biological transport of tailings to the surface water from zooplankton migration is also unlikely (see Section 4.2.2.2). Tailings spills

would be confined to an estimated 1 hectare area near shore in the middle basin (see Appendix G, Section 16). Impacts would be similar to those described in Section 4.2.2.2 except probably a lower density of juvenile salmon would be found in the upper water column area than in the inner basin. Significant impacts from a tailings spill are not anticipated.

Impacts of tailings discharge on local sport and commercial harvest of demersal fish, crabs, and shrimp would be similar but possibly less than that of direct inner basin discharge (Table 4-12). The deep water habitats would be impacted for more years than would occur from the inner basin discharge, but the shallow water (less than 100 m) habitats, where the highest densities of dungeness crabs are found, would be less impacted. Also, the region where spot and coonstripe shrimp were most abundant (less than 150 m) would be impacted less. As suggested in Table 4-12, loss of commercial species most heavily harvested in these fjords should be less with direct middle basin discharge (see Section 4.2.2.2).

The effects on the marine community after plant closure are discussed in Section 4.2.2.2. The effects would be mostly confined to the middle basin below 150 m deep.

4.2.2.4 Tunnel Creek Mill with Tailings Disposal to Boca de Quadra and Townsite

This alternative would have the same impacts as the alternative discussed in Section 4.2.2.2, with the following exceptions.

During construction of the roads to the townsite, considerable blasting would occur. Explosions in water can have severe effects on fish, but the greater the distance from the explosion, the less effect it has. Hill (1978, p. 16) states that shock waves in water from explosions usually cause no damage at a maximum of a few hundred meters, except for a very large explosion. He also states that charges placed in the bottom sediment have a shock wave reduction rate twice that of water for the same distance. The potential effects of road blasting on fish are discussed in the proposed project. No significant mortalities should occur if blasting is maintained away from the water's edge.

An optional wharf site would be located about 1,000 ft farther upfjord. This facility would have slightly more impact to marine organisms than the proposed wharf. With this optional wharf site location, the only wharf fill areas (temporary barge landing facility and boat launch) would remain the same as with the first wharf option (described in Section 4.2.2.2). Therefore impacts from fill would remain the same as the first wharf option. But increased dredging, because of its shallower depth, would be required for boat traffic at the floating wharf. The floating wharf dock and marina would be closer to the estuary. In either case, the habitat is of the same type utilized by juvenile salmon, but the facilities would be closer to high density juvenile salmon areas, thus increasing the potential for impact to feeding juvenile salmon (VTN 1982e, p. 50).

Construction of a Bakewell Arm townsite and connecting road would cause some initial marine benthic organisms to be directly smothered by sidecast rock debris along the 9 mi road constructed along the east shore of Wilson and Bakewell arms (between the wharf and the Bakewell townsite). Because of the steep shores, most of the sediment would fall to the deepest parts of Wilson and Bakewell arms. Some sediment may remain suspended transiently, reducing primary production. The effect would be local and short term and would not constitute a significant impact.

During operations, sediment runoff from the townsite and road into Bakewell Arm could continue to inhibit primary production annually but the affected area would be small, and the occurrence sporadic and brief. The overall impact to the marine environment would be insignificant.

The largest impact of the townsite would derive from increased fishing pressure on marine resources. An ADF&G (1980) study found that for a town of 1,500 people, 450 sport fishing licenses would be purchased. Also, Mills (1982) stated that on the average 11 halibut and 50 rockfish are caught annually per household that responded to the survey. This indicates that if 2,000 residents were located at Bakewell and all of their fishing occurred in that area, up to 6,600 halibut and 30,000 rockfish could be caught annually. Although halibut were present in long-line catches (VTN 1981d, p. 123), very few halibut were present in Wilson Arm/Smeaton Bay otter trawl surveys (VTN 1981d, p. 96, 1982g). Most harvest of halibut therefore would probably occur beyond the fjord. Rockfish present along the rocky shoreline areas could be highly impacted because they grow slowly and may exhibit homesite behavior (Carlson and Haight 1972). This indicates the rate at which the rockfish would be replaced by immigrants would be slow. Although very little local commercial harvest is reported, some may occur. Insufficient data are available to estimate rockfish populations along the rock wall areas, where they would be most abundant, but sample hook and line catches indicate fair abundance in Wilson Bay/Smeaton Arm (VTN 1981d, p. 131). It is most probable that sport harvest by the residents of the Bakewell townsite would dominate any sport fishing that normally occurred in this area.

Sport harvest of dungeness crab would also increase in upper Bakewell and Wilson arms. Because most dungeness crab fishing is concentrated in relatively shallow waters (usually less than 7 fathoms; Koeneman 1983b) in southeast Alaska, these areas would be highly impacted by local fishing. Most of this habitat is found in the upper ends of Wilson and Bakewell arms. Recreational shrimp fishing may also increase.

During temporary shutdown, recolonization would occur in benthic areas in Boca de Quadra that had previously been undergoing rapid deposition of tailings. Based on in situ estimates by VTN (1983m, p. 45) of recolonization on tailings, the area could be completely recolonized in 25 months or less. These data may not be absolute, as the environmental characteristics with the whole basin covered may be different. Areas

that received heavy sediment from continuing slumping events would take longer to recolonize. Some road runoff from slides in the Wilson Arm/Smeaton Bay area would continue, but runoff from vehicle traffic would greatly diminish.

All post-operation impacts would be the same as described in Section 4.2.2.2 except as noted. Reduced sport fishing pressure would result in marine fish and shellfish stocks returning to preoperation levels in Wilson Arm/Smeaton Bay after several years. Species like rockfish may take the longest to reestablish because of their longevity and slow growth rate. For example, it has been found in one heavily fished population of rockfish off the Queen Charlotte Islands that it would take more than a decade of greatly reduced fishing pressure to significantly increase population size (Archibald et al. 1983, p. 293).

Construction of Wilson Townsites I or IIa could result in higher sediment input into the Wilson estuary, particularly because of the large amount of fill required. It is anticipated that adequate treatment of the runoff during construction would reduce sediment runoff to insignificant levels.

During operations, the ultimate effect of Wilson I or IIa on sport fishing in the marine environment would be the same as the Bakewell site, as the same number of families would be living at any of the sites. Even though townsite residents do not have direct access to the marine environment, it is assumed access would be provided by way of the wharf on the east side of Wilson Arm. Project closure impacts would be the same as for the Bakewell townsite.

4.2.2.5 Tunnel Creek Mill with Tailings Disposal to Wilson Arm

The main differences in impact between this alternative and the project described in Section 4.2.2.2 would be tailings disposal in Wilson Arm/Smeaton Bay and not in Boca de Quadra, and increased road widening (8 ft in the Wilson-Blossom nearshore).

During construction, increased road width resulting from an 8-ft-wide trench for tailings lines would increase the amount of nearshore habitat lost by 0.2 ac, exclusive of the existing access road, to a total of 0.4 ac lost. This loss would consist mainly of steep, rocky shoreline habitat, which is important rearing habitat for chum, chinook, and pink salmon. Some disruption and loss of important marine food organisms would occur in the first year. This small loss would be insignificant as far as major marine fisheries resources are concerned. Recolonization after the first year would result in no further losses of these organisms.

Sediment input from construction-induced slide activity would be about the same as described in Section 4.2.2.2.

The two, 24-inch tailings pipelines would enter the fjord at the wharf facility so no additional nearshore habitat would be lost.

Minor impacts to feeding salmon in the wharf area could occur if construction occurs during peak abundance of juvenile in the nearshore area (April-June; VTN 1982e, p. 50). At other periods, effects would be insignificant, although some feeding by nearshore fish such as herring and sandlance may be temporarily disrupted. After construction, impacts from pipe location should not be significant as marine organisms would reestablish in the area, but periodic disturbance from pipe rotation or replacement (4 months to 3 years) could affect these areas slightly.

The installation of an 8-ft-wide trench along the road would not increase road runoff significantly because the area would be seeded and not be disturbed. Total annual road runoff from operation would be about the same as described in Section 4.2.2.2.

The main operational impacts of this alternative would occur as a result of tailings disposal. Direct loss of benthic marine habitat and organisms in Wilson Arm, Smeaton Bay, and Bakewell Arm would occur.

Based on the estimated density of tailings and the expected slope that tailings can occupy, Findikakis (1985, p. 36) presented an expected depth and distribution of tailings in Smeaton Bay, Wilson Arm, and Bakewell Arm. The density and slope assumed in these models are considered to be the most accurate information available, but the final slope and density may differ. Based on these figures and Island Copper discharge plume studies (Rescan 1983), it was assumed that impacts from burial would occur 65 ft (20 m) shallower than depth of fill (see Section 4.2.2.2 for discussion of density plume above bottom). The resulting range of fill, average depth of fill, and values adjusted for the high density turbidity plume are 75 m (245 ft), 90 m (295 ft), and 115 m (375 ft) for Wilson Arm, Bakewell Arm, and Smeaton Bay, respectively.

As discussed in Section 4.2.2.2, recolonization is expected to occur, although complete recolonization will take longer than a year. The main impact would be from the high deposition rate smothering benthic organisms and their habitat, ultimately affecting other demersal organisms that feed on them. See discussion in Section 4.2.2.2 for general effects of burial of benthic organisms from tailings discharge. Because not all of the area under the ultimate fill would have a high sedimentation rate every year, the estimated losses were adjusted based on predictions of area being actively covered by tailings during any one year from Boca de Quadra models. From these, a multiplication value was derived to estimate total losses from burial during the life of the project. Total estimated loss based on the representative commercially important benthic organisms would be 14,070 kg/yr (Table 4-12). This is the second highest loss of benthic organisms based on the four marine discharge options proposed. Much of the loss is due to impacts to a higher density region of the bottom for commercially important species such as dungeness crab, which are more abundant in water less than 100 m deep, and spot and coonstripe shrimp, which are most abundant in water less than 150 m. It should be noted

that these estimates of loss are based on many untested assumptions and represent more of an index of loss than a true measure of total benthic organism loss. Derivation of this factor and other calculations are shown in Appendix G, Section 9. Effects on benthic organisms and their habitat would be similar to those discussed in Section 4.2.2.2. Consequently, we assumed temporary loss of marine life below the adjusted mean depth in areas of active annual fill indicated in Wilson Arm, Smeaton Bay, and Bakewell Arm. For the purpose of estimating loss, it was assumed that no recolonization occurred in areas of active deposition for one year and that total recolonization occurred after one year.

Eulachon may also be impacted from the high density tailings plume near the bottom. Apparently some eulachon that migrate to the Wilson River (an estimated spawning population of 30,000) during the spring travel near the bottom as indicated by high spring catches in otter trawls in Smeaton Bay (VTN 1982h, pp. 34 and 58). Losses could be significant, but it is expected that they would avoid the high density plume during migration.

Suspended sediments may also impact some marine organisms, depending on what depth and concentration the material reaches. A model by Kowalik and Findikakis (1985) estimates the two-dimensional distribution of a tailings cloud in Wilson Arm/Smeaton Bay. Like the Kowalik (1984) model for Boca de Quadra, it does not predict the area that tailings will cover, only average up- and downfjord distribution. Based on the assumption of 200 to 600 mg/l in the lower tailings plume, the upper plume would be less than 1 mg/l above 60 m depth, well below the photic zone. Values of 2 to 6, 20 to 60, and 100 to 300 mg/l would be found at approximately 80 m, 90 m, and 100 m, respectively, over most of the length of the basin. This plume would extend from the base of the estuary to the outer sill of Smeaton Bay. Also, major slumping events may occasionally bring sediment near or into the surface water of a small part of the fjord (see physical oceanography impacts, Section 4.1.6.5). If the suspended sediments reach the photic zone, primary production may temporarily decrease for up to a few days, the availability of pelagic zooplankton used as food by young salmon and herring and other pelagic feeding organisms may similarly decrease, and the migrating behavior of the juvenile anadromous fish may be temporarily altered. If the suspended sediment remains below the photic zone, then these impacts would not likely occur. Some migratory zooplankton that are components of the diet of some pelagic fish are found below the photic zone. Some of these species may be impacted from a tailings plume but, as discussed in Section 4.2.2.2, concentrations generally less than 100 mg/l to 250 mg/l have not been found to affect feeding success of zooplankton. Some of the migratory species may be impacted at depths in the vicinity of 100 m. The overall impact to migratory zooplankton and ultimately fish that feed on these species appears to be minor, although the exact effect cannot be determined.

Overwintering herring habitat in Wilson Arm/Smeaton Bay may be affected from either direct burial or from suspended tailings. The actual effect on herring abundance and distribution cannot be determined, but may be less than discharge to the inner basin of Boca de Quadra if actual abundance of herring is less in this bay. The number of overwintering herring in Wilson Arm/Smeaton Bay is not known, but is thought to be less than in Boca de Quadra (Blankenbeckler 1985). Some age 1 fish overwinter in Wilson Arm/Smeaton Bay, but apparently few other age classes are present (VTN 1982i, pp. 35-41; Minicucci 1983). Although sampling was not directly comparable between the two fjords, abundance of herring, other than larvae, appeared higher in the Boca de Quadra inner basin than in Wilson Arm (VTN 1982i, pp. 19-22, 35-37, and 51). Boca de Quadra is also closer to the area of major herring spawning at Kah Shakes. As discussed in Section 4.2.2.2, three methods were used to estimate potential impacts to herring habitat (Table 4-13). The first two methods estimate impacted habitat from burial of regions less than 140 m deep. The third method estimates volumes of water less than 140 m deep with tailings concentrations that have been found to be avoided by Atlantic herring (greater than 20 mg/l). The depth and concentration of suspended solids from tailings discharges in Wilson Arm/Smeaton Bay are based on the models of Kowalik and Findikakis (1985). As stated in Section 4.2.2.2, using these methods to estimate areas of concentration may be erroneous. Also, herring may be able to alter their distribution relative to bottom changes or tailings plume without direct loss of herring. Because of the absence of more specific information about distribution, abundance, and behavior of herring within Smeaton Bay/Wilson Area, more definite conclusions about impacts to herring from tailings discharge are unreasonable.

Only a low concentration of fine tailings material is predicted to pass over the Smeaton Bay sill at 150 m depth (Kowalik and Findikakis 1985). Tailings of concentrations of 2 to 6 mg/l will pass beyond the outer sill at a depth of about 80 m (Kowalik and Findikakis 1985, p. 67). The small amounts of tailings traveling below the photic zone are not expected to significantly increase sediment beyond the sill and would have no significant impacts.

All other impacts not discussed would be similar to those considered in Section 4.2.2.2 except they would occur in Wilson Arm/Smeaton Bay (see Table 4-12).

Slightly increased sport fishing activity may occur in Wilson Arm/ Smeaton Bay during construction. The net effect would be insignificant because of the limited leisure time provided workers as well as restricted access.

The Bakewell Arm and Wilson I and IIa townsite impacts would be the same as discussed previously.

After project shutdown, some remaining impacts after the completion of designated reclamation activities would occur. Roads, tunnel areas, wharf, and other facility areas should contribute minor quantities of sediment runoff after reseeding, resulting in insignificant impacts in the marine environments of Wilson Arm/Smeaton Bay. Residual impacts to the marine environment of Wilson Arm/Smeaton Bay from tailings disposal may occur indefinitely, but should be greatly reduced within 10 years after shutdown. The natural sedimentation rate in Wilson Arm/Smeaton Bay, which would help bury tailings, is similar to Boca de Quadra, ranging from 0.2 to 0.9 cm/yr (Burrell 1983, Appendix 2, p. 10). Some natural movement of bottom sediment after deposition has been observed in Wilson Arm/Smeaton Bay; most movement is apparently from slumping of sediment (Burrell 1983, pp. 21-22). The exact redistribution of sediment is not clear. It is possible that this activity could keep part of the tailings on the surface sediment and in the water column. As discussed in the operation portion of Section 4.2.2.2, recolonization of these sediments may not be the same as natural sediment, but could be fairly rapid. Based on VTN (1983m, p. 45) in situ tailings studies, complete recolonization could occur within 25 months. The real situation may be different when a large portion of the basin is covered and some organisms, such as clams, may take longer to recolonize. Most areas of the two basins would be near "normal" in sediment composition after a few years. The reasons are discussed in Section 4.2.2.2.

Temporary shutdown would have the same effects as described in Section 4.2.2.2.

The depth of the sediment surface may be as shallow as 230 ft (70 m) in some areas by the end of the project. Some important organisms, such as spot prawns, are often abundant in depths of 295 ft (90 m) (Butler 1980, p. 141). Ultimately, a healthy community should reestablish on the sediment as they become more "natural." However, it would probably not be the same as the premining community because of the possible loss of shrimp habitat, although an increase in dungeness crab habitat may occur, as they prefer shallower depths than much of the present basin. The net result cannot be predicted, but the resulting shallower basin could be more productive.

Impacts of town removal would be the same as those for Bakewell and Wilson I and IIa.

4.2.2.6 Beaver Creek Mill with Tailings Disposal to Boca de Quadra

This alternative would have the same impacts as described in Section 4.2.2.2 or Section 4.2.2.3 depending on whether tailings discharge is initially to the inner basin or directly to the middle basin, respectively, except as stated below. This option considered two tunnel alignments for the tailings disposal line from the mill to Boca de Quadra inner basin with the option of extending either to the middle basin. Without an access road and other facilities in the Tunnel Creek valley, sediment input from the project to Wilson Arm would be reduced

by about 390 tons/yr or 1 percent of the average annual input. This reduction would be insignificant as far as impacts to the marine organisms in Wilson Arm/Smeaton Bay.

One tunnel option has the tailings line emerging above the Keta River estuary and a surface pipeline extending to the same discharge location as stated in Section 4.2.2.2. During the construction phase, a pad at the tailings tunnel portal would be located above the Keta River estuary. All of the rock from tunnel excavation would be used for the pad construction so none would enter the estuary. Sediment runoff from the pad construction and tailings and road installation along the steep shore area may result in minor input of fines from runoff. Because of the small area that would be disturbed, the resultant sediment runoff during construction into the estuary and inner Boca de Quadra would be insignificant. After construction, runoff would be reduced. Surface access for construction of the pipeline would extend from a small dock on Boca de Quadra to the portal. The road would not fill any estuary area. Effects from wharf construction in the steep fjord area are expected to be insignificant, although some local burial of marine organisms would occur during construction, possibly impacting juvenile salmon in the area.

The other tunnel alignment goes directly to the inner basin at the same location as described in Section 4.2.2.2. Excess rock from the tunnel would be deposited in the fjord. The excess rock would equal an area of about 0.6 ac of bottom covered at 30 ft deep (U.S. Borax 1985d). Impacts from this deposition would result in some initial loss of benthic organisms, particularly deeper benthic organisms where most of the rock would go because of the steep walls on the fjord.

The benthic loss would be short term, as the region would become mostly recolonized within a year. The impacts would not be significant.

Operational impacts from this alternative would be the same as described in Section 4.2.2.2 if discharge was initially to the inner basin, or the same as in Section 4.2.2.3 if discharge was directly to the middle basin with no discharge to the inner basin. Impacts of a spill of tailings due to pipeline rupture are discussed in Appendix G, Section 16. A spill into the Keta estuary may have significant impacts on feeding juvenile salmon if it were to occur in periods of peak abundance (April-June). Benthic organisms important as salmon food, such as harpacticoids and chironomids, would be lost and production decreased until the organisms reestablished in the area. Impacts of the townsites at Bakewell Arm or Wilson I or IIa would be the same as discussed previously. Townsite removal would have the same impacts as the Tunnel Creek mill with Boca de Quadra tailings disposal and townsite concept alternative for the Bakewell Arm and Wilson I and IIa townsites.

Impacts from the option of extending the pipeline along the fjord to the middle basin could cause minor disruption of feeding juvenile salmon or herring as discussed in Section 4.2.2.2, even if no discharge occurs in the inner basin.

4.2.2.7 Beaver Creek Mill with Tailings Disposal to Wilson Arm

This alternative has similar impacts on the marine and estuarine environment as the Tunnel Creek mill with Wilson Arm tailings disposal. The main difference is the increased loss of estuarine habitat from the addition of an 8-ft-wide trench for the tailings line along the access road. This would result in an addition of 0.8 ac of habitat loss. This equals a total loss of 2.3 ac or 0.7 percent of the 320 ac estuary. Impacts of estuary burial would be similar to those discussed in Section 4.2.2.2.

The only difference consists of reduced sediment input because no road would be constructed up Tunnel Creek. This would reduce operational sediment input into the fjord by 390 tons/yr or 1 percent of the normal average sediment input. No increased operational sediment runoff would occur from an 8-ft-wide pipeline trench added along 7.6 mi of access road to the Beaver Creek site because the area would be seeded.

If the power plant remains in Tunnel Creek, operational runoff of sediment would be increased by about 390 tons/yr or 4 percent of the average annual input. The resulting impact would still be about the same as the previously mentioned option.

Impacts and probabilities of a spill of tailings due to pipeline rupture are discussed in Appendix G, Section 16. Impacts to Wilson Arm are expected to be locally severe, and possibly significant if they occur during peak juvenile salmon abundance.

Project closure and temporary shutdown impacts would be the same as the Tunnel Creek mill with Wilson Arm tailings disposal.

4.2.2.8 Beaver Creek Mill with On-Land Tailings Disposal

The main impacts from this option are potential catastrophic effects on estuarine and marine fish and invertebrates in both Boca de Quadra and Wilson Arm from a tailings dam failure.

Construction effects involving estuarine habitat loss and sediment input would be about the same in Wilson Arm/Smeaton Bay as described in Section 4.2.2.2 because of similar roads and plant construction. The access road connecting the Keta wharf and tailings line would remain above the estuary and would not cover any estuarine habitat.

Establishment of a 6-ac dock area would cover some rocky intertidal and mud sand subtidal habitat just downfjord of the Keta River delta. Most of the 6 ac would be leveled area above the high tide line. Design would be similar to that described in Section 4.2.2.2 for the Wilson Arm wharf, with very little intertidal fill for dock facilities except for an initial construction barge slip. The small amount of fill would result in initial mortalities of benthic organisms but the area would become reestablished with benthic organisms within a year. The types of impacts discussed in Section 4.2.2.2 would be similar to those at this site. The net effect of a wharf on important marine resources in this area should be insignificant.

Minor sediment increase (sand and smaller) would result from construction of the tunnel and the tailings pipeline above the Keta River estuary and Aronitz Creek. Most impacts would happen during the first year from increased slides induced by construction. The small area disturbed would contribute insignificant amounts of sediment to the estuary and Boca de Quadra inner basin.

During the operational phase of the project, runoff of sediments from roads in Wilson Arm/Smeaton Bay would be similar to those described in Section 4.2.2.2 because absence of an access road to Tunnel Creek would be offset by one to the tailings dam. Sediment inputs to the Boca de Quadra inner basin would only increase slightly.

The lack of tailings discharge to the marine environment would eliminate all impacts in either basin associated with these discharges. The largest impact from this proposed alternative would result from a tailings dam failure. If a total failure occurred when the dam was nearly full, it would kill all organisms in the estuary of Boca de Quadra and in the inner basin from smothering or high suspended solids concentrations. Mortality might occur in the middle basin, but probably not into the outer basin, although high turbidity water would be present, reducing primary production and impeding feeding by zooplankton.

If a dam break occurred in Tunnel Creek, a situation similar to that in Boca de Quadra would probably occur with very high mortalities in Wilson Arm. Some initial mortalities may extend into Bakewell Arm and Smeaton Bay, but probably none beyond.

Residual effects of a dam failure might extend over several years, with increased turbidity retarding primary production for several years in the inner sections of Boca de Quadra or Wilson Arm. This reduced production could diminish populations of suspension-feeding benthic organisms that are dependent on phytoplankton production. Such reductions could conceivably result in effects on important species of fish, crab, or shrimp that depend on those benthic organisms.

Impacts of a rupture of the tailings pipeline, as discussed in Appendix G, Section 16, are expected to be similar to those of other alternatives with spills in the Keta estuary.

Impacts from townsites in Bakewell Arm and Wilson I and IIa would be the same as those discussed previously.

During the project closure phase, roads, facility areas, and work areas would be rehabilitated. After rehabilitation, sediment input to the marine environment of Boca de Quadra and Wilson Arm/Smeaton Bay should not be significantly higher than the premine levels, although cut bank slides along the road may occur infrequently.

The danger of a large earth dam failure on the Aronitz Creek drainage or the Tunnel Creek drainage would be present indefinitely. The impacts of dam failures are discussed above.

If no dam failures occur, this option would not have the potentially long-term effects on marine ecology that are associated with marine tailings disposal options.

4.2.2.9 North Meadow Mill with Tailings Disposal to Boca de Quadra

This option would have the same impacts as the first discharge alternative described in Section 4.2.2.2 for tailings discharge if the discharge is only to the inner basin. If tailings discharge were moved to the middle basin, impacts from tailings would be the same as the second subalternative with Boca de Quadra tailings disposal. All other impacts would be the same as described in Section 4.2.2.2 except as discussed below.

The lower end of the proposed access road for this Keta alternative would cross about 500 yds of the upper Keta River estuary. Assuming a road width of 48 ft, including the 36 ft roadbed and the fill slopes of the road, a total area of 3.3 ac of upper estuary would be covered during construction. This area is about 1.7 percent of the 200 ac estuary, which includes mainly herb/grass and sedge/*Fucus* habitat. A small channel running along the shore for most of the length would be inundated. These channels are often used for juvenile salmon rearing (particularly coho) during the spring and summer (Forest Service 1982a, p. 3-37). It would be anticipated that the lost channel would move farther into the estuary within a year, restoring this salmon habitat at the expense of sedge/*Fucus* or grass/herb habitat. Some locally produced prey organisms for salmon and other marine species, such as chironomids and harpacticoids (VTN 1982g), would be lost. In addition, the tailings pipeline and road needed for construction would bury habitat on the opposite side of the estuary. If we assume a road width of 18 ft, including a tailings line trough and a cleared area of 20 ft, giving a total width of 38 ft for length of 0.75 mi along the estuary, 3.4 ac or 1.7 percent of estuary habitat would be buried. This habitat is important feeding area for juvenile salmon. Initially, overall estuary production may be reduced, but with rechannelization, net loss to the estuary would be minimized.

With the burial of habitat on both sides of the estuary, the overall effect would be to reduce the estuary by 6.7 ac or 3.4 percent. These combined effects may significantly impact juvenile salmon because both shoreline areas of the estuary would be impacted.

Impacts from construction and operation of the tailings pipeline along the shore and down the estuary would be similar to those discussed for the Beaver Creek mill with Boca de Quadra tailings disposal.

Impacts from wharf installation would be the same as for the Beaver Creek mill with on-land tailings disposal.

During project operations, the average annual sediment input to Boca de Quadra from road use would increase as a result of road runoff during the life of the project of 1,800 tons/yr or about 8 percent of the average annual input. Losses of some species could occur the first year but populations should return to normal in subsequent years.

Shipping traffic in Boca de Quadra should not interfere with most commercial or sport fishing, as the size of Boca de Quadra allows for easy passage of several boats without danger. Commute traffic would consist of two trips daily on weekdays from Ketchikan with lesser frequencies of supply traffic. The only time any conflict with fishing may occur would be during the March/April gill net herring fishery near the mouth of Boca de Quadra. Because all of the commuting traffic would occur during daylight hours, most boat traffic should be able to avoid the gill net fishing vessels. Supply vessels would need to be especially careful during these months to avoid encountering gill net vessels in the area.

Because most of the workers would be working 12-hour days (7 days on and 7 days off) and leaving on their days off, local fishing pressure on Boca de Quadra would be insignificant. Because no activity is scheduled for Wilson Arm/Smeaton Bay, no increase in fishing pressure would occur there.

If the bulk sampling road is reclaimed, sedimentation impacts to Wilson Arm/Smeaton Bay would be reduced from levels in that area described in Section 4.2.2.2. Some remaining impacts due to sudden sediment input from infrequent landslides may result from the former road cut banks, but the effects would be insignificant.

Impacts from a tailings spill above the estuary could be significant, affecting feeding juvenile salmon (see Appendix G, Section 16 for discussion of tailings spill effects).

The Keta townsite is the only townsite associated with the Keta River access road. Increased sediment runoff from the 120 ac townsite could occur in the Keta River estuary. It is anticipated that proper sediment treatment facilities would be in place to handle sediment runoff so that impacts to the Keta estuary would not be significant. Townsite construction would encroach on the upper estuary covering about 3,000 sq ft of the estuary tidal channel, which would supply good rearing habitat for juvenile (pink, chum, and coho) salmon. This loss would be less than 0.1 percent of the estuary. Although this loss of habitat would probably not be replaced by a channel, the percent of estuary is small and insignificant. Impact of fishing pressure (i.e., number of fish caught) would be the same in Boca de Quadra as it would be in Wilson Arm/Smeaton Bay for the Bakewell townsite.

The impact on sport harvest by local sportspersons from Ketchikan would be less as fewer people fish this fjord (ADF&G 1980). Conversely, commercial harvest of crab and shrimp from this area is higher than in Wilson Arm/Smeaton Bay (Appendix G, Tables 7-1 and 7-2). Therefore, total annual commercial harvest (pounds of shrimp and crab) would be reduced to a greater extent from a townsite in this area than one in Wilson Arm/Smeaton Bay.

Postoperation and temporary shutdown impacts from this option would be the same as those discussed in Section 4.2.2.2 except as noted. Any minor sediment runoff after rehabilitation would be mostly confined to the Keta River drainage because the access road would be subject to infrequent slides. Residual sediment runoff into Wilson Arm would be less than described in Section 4.2.2.2 if the former bulk sampling road has been rehabilitated near the start of the mining operation.

Dismantling the town near the Keta River estuary area would have the same impact on Boca de Quadra as the Bakewell townsite option would have on the Wilson Arm/Smeaton Bay area.

4.2.2.10 North Meadow Mill with On-Land Tailings Disposal

This option has the same construction and operation impacts as the Beaver Creek mill with on-land tailings disposal, except as noted below.

In the Boca de Quadra inner basin, increased slides caused during the first year of road construction in the Keta River drainage may increase input of fine material (sand and smaller) by 1,300 tons in the first year or 6 percent of the annual input. In addition, larger particles equal to the quantity of fines from the slides would continue to enter for several years. During the first year some species of invertebrates would probably be smothered, but many species can accommodate the predicted sedimentation, as discussed in Section 4.2.2.2.

Except for limited smothering of benthic organisms during the construction phase, no significant impacts from this alternative are anticipated. An exception could be rupture of the tailings pipeline (see Appendix G, Section 16). Due to the length of the pipeline, the largest volume of tailings of all alternatives could be spilled, depending on location. Effects on nonmobile benthos could be moderately significant due to the potential area affected.

This option would have the same project closure and temporary shutdown impacts as the Beaver Creek mill with on-land tailings disposal.

4.2.3 Vegetation and Wetlands

4.2.3.1 No Action

The no action alternative would leave the bulk sample access road in place. The 36 ac occupied by the roadbed would remain without vegetative cover as long as the road is maintained. The 66 adjacent acres, which were cleared for construction, and other acreage affected by debris slides would be revegetated, either from postconstruction revegetation efforts or from natural seed sources.

4.2.3.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

The greatest impact on vegetation from project construction involves direct disturbance or removal of vegetation from about 2,900 ac. The distribution of the disturbance among the vegetation types is given in Table 4-14. Vegetation changes would be long-term impacts, even though areas disturbed during construction would be reseeded upon completion of the disruptive activity or if no active use of the area is planned for two years. Vegetation types develop over many years in response to the conditions of substrate, drainage, and microclimate, which the project would alter. The succeeding vegetation would differ from what previously existed and would support less wildlife (Wallmo and Schoen 1980). Estuarine marsh would not form again on roadfill, muskeg would probably not develop on a waste rock pile, and a forest may require hundreds of years to reach maturity even on suitable substrate. However, even with substantial changes in the vegetation types of the project area, the changes would affect only a fraction of a percent of each vegetation type in the region.1/ Therefore, the impacts may be moderate or significant on a local level but insignificant regionally.

Portions of wetlands of several types would be eliminated by various project components. These have been summarized in Table 4-14 and are illustrated in Figure 4-19. The wetlands that would be filled to accommodate project facilities include about 1.5 ac of estuarine meadow, less than 1 ac of intertidal marine habitat, about 3.5 ac of freshwater marsh with a small amount of swamp intermixed, and up to about 600 ac of muskeg (including herbaceous muskeg, forested muskeg, and some riparian wetlands). Muskeg is so common in the region that the loss of 600 ac is only a fraction of a percent.

Operational impacts on vegetation from dust and from snow removal would be localized to roadsides and the snow disposal areas. The impact, a reduction in productivity, would be insignificant.

1/ The region, for purposes of vegetation and wildlife impact assessment, is defined as the section of Misty Fiords National Monument bounded by Rudyerd Bay on the north and Boca de Quadra on the south, and extending eastward to Portland Canal, an area of about 1,800 sq mi or about five times the size of the nonwilderness area of the Monument. The area includes adjacent estuaries and the adjacent mountain goat census areas of ADF&G.

TABLE 4-14

VEGETATION DISTURBANCE BY PROJECT COMPONENTS

Project Component	Total Acreage 1/	Vegetation Types Disturbed, 2/ Percentage of Total Area F	M	SA	E	R	AC	FW	A
Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option									
Mine pit	1,040	45	16	26	0	11	2	<1	<1
Waste rock, crusher, mine services, roads, camp, etc.	1,550	61	13	<1	0	16	8	2	0
Tunnel Creek processing plant and associated facilities	210	85	0	0	0	15	0	0	0
Tunnel Creek reservoir	65	60	0	0	0	40	0	0	0
Boca de Quadra tailings tunnel portal	22	100	0	0	0	0	0	0	0
Wilson wharf expansion	6	100	0	0	0	0	0	0	0
Tunnel Creek access road	21	95	0	0	0	5	0	0	0
Mine road expansion	21	86	7	0	7	0	0	0	0
Blossom River water supply access road	5	50	0	0	0	50	0	0	0
TOTAL	2,940								
Townsites									
Bakewell	200	29	70	0	<1	<1	0	0	0
Wilson I	120	90	<1	0	0	5	0	5	0
Wilson IIa	200	90	5	0	0	5	0	<1	0
Keta	120	75	0	0	<1	10	0	15	0

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TABLE 4-14 (Continued)

VEGETATION DISTURBANCE BY PROJECT COMPONENTS

Project Component	Total Acreage 1/	Vegetation Types Disturbed, 2/ Percentage of Total Area							
		F	M	SA	E	R	AC	FW	A
Alternate Water Reservoirs									
Raspberry Creek	180	8	0	84	0	0	0	8	0
Hill Creek	100	50	30	20	0	0	0	0	0
Upper Lakes	87	90	10	0	0	0	0	0	0
North Meadow	170	35	55	0	0	5	5	0	0
On-Land Tailings Impoundments									
Tunnel Creek	1,400	85	<1	0	0	10	5	0	0
dam and construction	250								
Aronitz Creek	1,300	85	5	0	0	5	5	0	0
dam and construction	170								
Tailings pipeline	4	70	10	0	0	20	0	0	0
Keta access road	95	50	5	0	4	36	5	<1	0
Estimated thousands of acres of each vegetation type in the region		600	120	160	2	11	11	4	220

1/ Approximate acreages for ultimate development.

2/ F - forest; M - muskeg; SA - subalpine; E - estuarine meadow; R - riparian; AC - avalanche chute; FW - freshwater marsh; A - alpine

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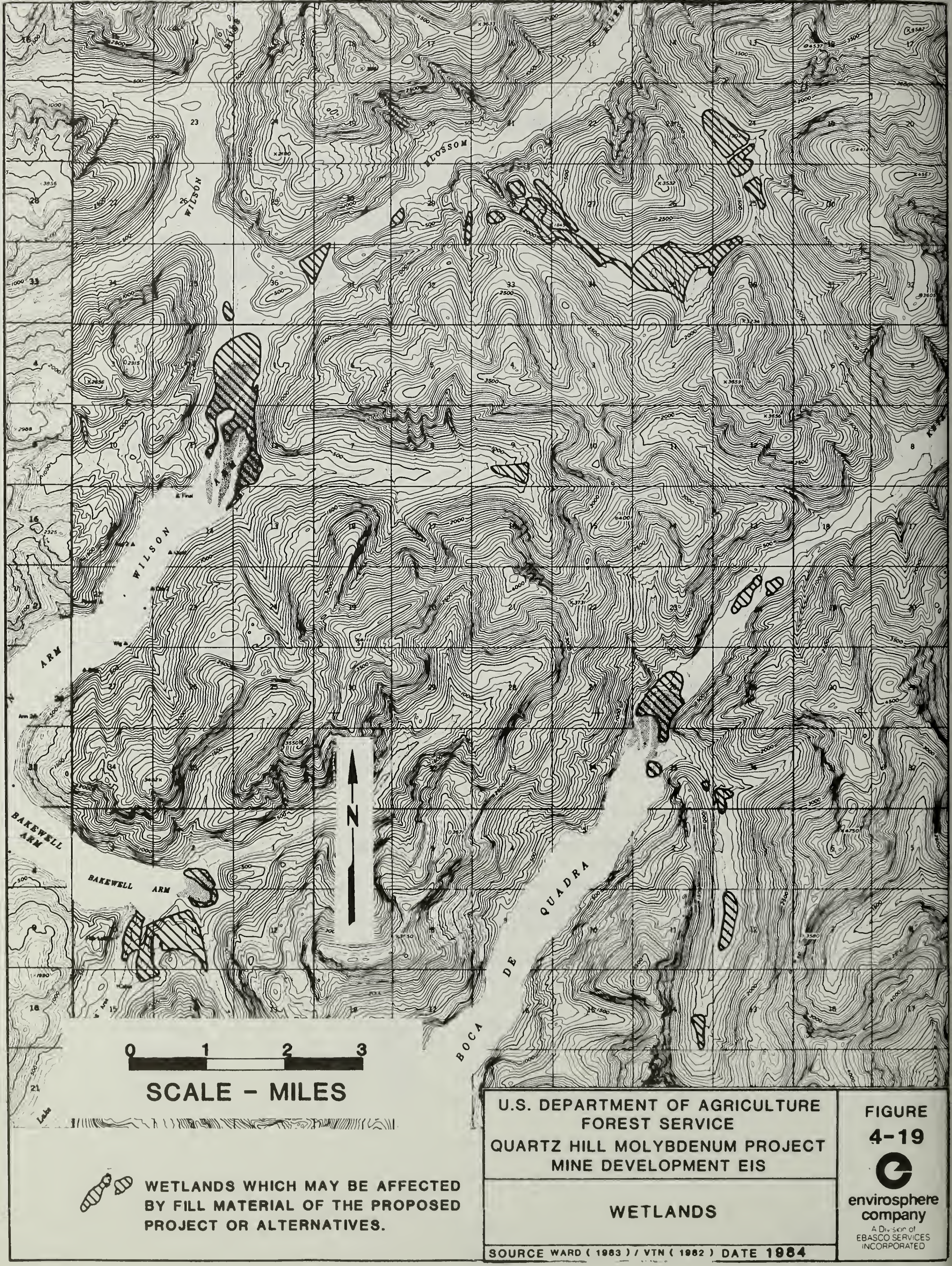

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

WETLANDS

SOURCE WARD (1983) / VTN (1982) DATE 1984

FIGURE 4-19

envirosphere company
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Other impacts of the project relate to events of uncertain probability such as fuel and tailings spills, wind throw, and airborne emissions. If a major fuel oil spill occurred near the Wilson River estuary, the direct impacts of fuel toxicity and indirect impacts resulting from cleanup efforts would be substantial (see Appendix G, Section 14). A total loss of productivity could be expected for at least 1 year, and recovery of the estuarine habitat could require 10 years or more. Such an event could have regional significance because the region has a limited number of these important habitat areas, and the Wilson estuary is one of the largest. A small oil spill would have only local effects. A tailings spill would inundate vegetation in its path, possibly smothering or removing low growing species and contributing to increased erosion. A tailings spill would probably affect only a few acres downslope from the break (Appendix G, Section 16). Vegetation would probably recover or reestablish within a few years, except for severely scoured areas.

Where timber is removed in large blocks, additional forest is often blown down along the edges during wind storms. This would possibly occur in the Tunnel Creek valley or other areas where sizable blocks of forest are removed. Airborne emissions from the power plant, incinerator, and vehicles would include sulfur dioxide, which can be toxic to plants. The most sensitive plants are lichens and mosses (Winner and Bewley 1978), which grow on the surfaces of trees and constitute an important component of the winter diet of mountain goats (VTN 1982k, p. 56). The concentration of SO_2 resulting from this project would be too low to affect even epiphytic lichens and mosses in goat winter habitat.

4.2.3.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

For this alternative, the effects of building a townsite would be added to the effects of the other components described in Section 4.2.3.2. At the preferred townsite at Bakewell Arm, about 200 ac would be occupied by the town. About 70 percent of the area is muskeg or forested muskeg and the remainder spruce-hemlock forest. Several plant species were found only here during project area studies, but none are protected. Construction of an access road from the Bakewell townsite to the Wilson Arm wharf would remove an additional 24 ac of forest and about 1 ac of riparian habitat. If the road is in a tunnel for much of the way, fewer acres would be disturbed. The long-term removal or modification of this habitat would be insignificant in a regional context. If the town is built at the Wilson I or IIa townsites, about 120 or 200 ac, respectively, of spruce-hemlock forest would be removed. The access roads would remove 1 to 3 ac of riparian forest. This habitat loss would also be insignificant regionally.

If a tailings tunnel is driven directly to the middle basin of Boca de Quadra, the impact on vegetation would be similar to that from the tunnel to the inner basin. Extending the tailings pipeline from the tunnel portal in the inner basin to a discharge point in the middle basin would have essentially no impact on terrestrial vegetation because the pipeline would be under water.

4.2.3.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The effects of this alternative would be very similar to those described in Section 4.2.3.2. A few additional acres of forest would be eliminated by the pipeline corridor along the access road, but the 22 ac of forest along Boca de Quadra at the tailings tunnel portal would not be disturbed.

4.2.3.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

With the mill at Beaver Creek, an additional 70 ac of forest and muskeg would be disturbed at that site and an additional 50 ac of subalpine meadow would be occupied by the Raspberry Creek reservoir. The supplemental water pipeline would occupy a few acres of forest land along the access road corridor. The tailings would be conveyed by a launder in a tunnel, except for part of the route in the upper Tunnel Creek valley. Here, a surface pipeline would disturb about 20 ac of subalpine forest, meadow, and avalanche chute vegetation. An access road up the Tunnel Creek valley would remove an additional several acres of vegetation (mostly forest). A tailings pipeline rupture within this segment could inundate several acres of vegetation. The pipeline would also remove a few acres of forest along the shoreline of Boca de Quadra between the tunnel portal and the discharge point. The tunnel portal would be above the Keta estuary, and the forest removed would be of high value to wildlife. A pipeline break at this point would also have severe impacts to the estuarine marsh. A spill containment structure would probably be required here to minimize such impacts.

If the tailings tunnel is built from the Tunnel Creek opening to the portal location described in Section 4.2.3.2, the impacts would be reduced. Less vegetation would be lost, and the risk to the estuarine vegetation from spills would be removed.

If the employee camp and the power plant are not located in the Tunnel Creek valley, this would eliminate disturbance of about 225 ac of forest. These facilities would require fewer acres if located near the mill because access and a construction staging area would already be in place. Other impacts would be similar to those described in Section 4.2.3.2.

4.2.3.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

The effects on vegetation from this alternative would be similar to those of the Beaver Creek mill with Boca de Quadra tailings disposal. The tailings pipeline would parallel the access road, requiring about 10 ac to widen the road corridor, including about 0.8 ac of estuarine marsh and about 9 ac of forest. The areas that would have been occupied by the tailings route to Boca de Quadra would then be free from effects, including more than 20 ac in the Tunnel Creek valley and several acres at the tunnel portal and along Boca de Quadra. No access

road would be needed in the Tunnel Creek valley. The risk of a tailings spill would be greater than in the proposed project because of a greater distance of pipeline exposure and proximity to traffic, but acreage likely to be inundated would not be regionally significant.

4.2.3.7 Beaver Creek Mill with On-Land Tailings Disposal

The disposal of tailings on-land would require large impoundments in two valleys and construction of pipeline access to them. About 1,400 ac of Tunnel Creek valley would be occupied by one impoundment plus an estimated 250 ac for the dam and construction area. The Aronitz Creek valley would be the second location for on-land tailings disposal. The impoundment would occupy about 1,300 ac and the dam and construction area an estimated 170 ac. The vegetation types affected by both impoundments are given in Table 4-14. The tailings would be in tunnels for most of the distance but, where they cross the Keta River valley, they would be in a pipeline. Pumps would boost the flow to the Aronitz Creek tailings impoundment.

This alternative would expose sensitive estuarine and riparian habitat to potential tailings spills from failure of pipe or pumps. Access to tunnels and pipelines would remove additional acreage of sensitive vegetation types. Riparian habitats at the mouths of both Tunnel Creek and Aronitz Creek would be lost to construction activities. If a tailings dam were breached, a large area would be affected, including part of a sensitive estuary.

Other impacts of this alternative concept would be similar to the other Beaver Creek mill alternatives. The mine facilities, processing plant, and water supply would be the same for all three variations of tailings disposal.

4.2.3.8 North Meadow with Boca de Quadra Tailings Disposal

Siting the mill at North Meadow would include building the access road and wharf in the Keta River drainage. Tailings disposal in Boca de Quadra would require routing the tailings pipeline parallel to the access road and extending along the west side of the fjord to the discharge point. The vegetation removed by this corridor would be about 130 ac, about half of which is mature forest. The disturbed area would include about 6.7 ac (or about 3 percent) of the Keta estuarine marsh and extensive avalanche chutes, riparian forest, and muskeg areas. The water supply reservoir would be in a muskeg area in the upper reaches of Hill Creek, occupying an estimated 40 ac.

If this alternative is selected, development would not proceed in the Wilson Arm drainage. There would be no impacts in the Tunnel Creek valley and the bulk sampling wharf and road would be reclaimed. If a townsite is developed, it would be the Keta townsite, which would remove about 120 ac of vegetation (see Table 4-14). Other impacts would be similar to those described in Section 4.2.3.2.

4.2.3.9 North Meadow Mill with On-Land Tailings Disposal

No new impacts not discussed for other alternatives would be introduced by this alternative.

4.2.4 Wildlife Resources

4.2.4.1 No Action

The major effects of the no action alternative on wildlife relate to the bulk sample access road, which would remain in place. The road provides hunter access to high elevation mountain goat habitat and improves access for bear hunters, waterfowl hunters, and furbearer trappers. Local populations of these game animals would probably be reduced by hunting and poaching, but regional populations would probably remain unaffected. One mountain goat was harvested using access from the Quartz Hill camp in 1983 (Hervey 1984), illustrating the potential. The possibility of the road altering wildlife movement patterns has been discussed (Forest Service 1982a, p. 4-21) and, although possible, this is considered insignificant if vehicle and other activity is low.

4.2.4.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

Construction of the wharf expansion as proposed (Appendix A, Figure II-12) would have eliminated bald eagle nest number FWS 5, which would have been a violation of the Bald Eagle Protection Act. However, by special variance procedures the nest will be removed for educational purposes. It will be taken to the ANILCA information center in Ketchikan prior to the start of wharf construction.

The widening of the access road would place construction activities within the buffer zone of eagle nest number VTN 8. The nest is in good condition, but has not been occupied since 1980 when VTN's eagle surveys started. The bulk sampling access road was allowed to be within the buffer zone of this eagle nest through a variance and, presumably, a variance would allow the wider road. The fuel oil storage facility is now proposed for the upslope side of the road where it should not directly affect use of this eagle nest.

Eight additional eagle nest sites are within 0.5 mi of sites slated for construction of the Wilson Arm wharf expansion, the access roads, and the tailings tunnel portal at Boca de Quadra (Table 4-15). More exact distances will not be known until design details are more complete. Without specific controls, blasting, traffic noise, and other construction activities within 0.5 mi may cause the eagles to abandon their nest and not rear young that year (Forest Service 1983c). During construction of the bulk sample access road, construction activities were controlled by a "Bald Eagle Action Plan" (Forest Service 1983c) to prevent impacts; and similar restrictions will be required for project development to comply with U.S. Fish and Wildlife Service and Forest Service regulations.

TABLE 4-15

BALD EAGLE NESTS WITHIN 0.5 MILE OF PROPOSED PROJECT CONSTRUCTION

Nest 1/ Number	Nearby 2/ Construction	Distance (ft) 3/	Nest 1/ Condition	Nesting Activity 5/
FWS 5	Wilson Wharf	0	Good	Active 1983
FWS 7	Mine Access Road Tunnel Creek Access	330 4/	Fair	Inactive 1983
VTN 1	Mine Access Road	360	Good	Inactive 1983
VTN 8	Mine Access Road	165	Good	Inactive 1983
VTN 9	Mine Access Road	330	Good	Active 1983
VTN 16	Mine Access Road	4/	Good	Inactive 1982
VTN 11	Water Supply Access	4/	Good	Inactive 1982
VTN 12	Water Supply Access	4/	Good	Inactive 1982
FWS 11	Tailings Tunnel Portal	4/	Good	Active 1982
FWS 12	Tailings Tunnel Portal	4/	Remnant	Inactive 1982

1/ Source: VTN 1982d.

2/ For nest locations, refer to Figure 3-38.

3/ Pool Engineering 1982 (Eagle nest tree location surveys).

4/ These nests are within 0.5 mile of proposed construction, but exact distances remain unsurveyed.

5/ 1983 observations are from Prather (1983); 1982 observations are from VTN (1982d, Appendix F).

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In late summer and fall, and again in March, when eagles are concentrated along the lower Wilson and Blossom rivers, human activities may alter eagle feeding patterns, displacing birds to marginal habitat. However, eagles occur in towns such as Ketchikan, indicating they may habituate to human activity. In the unlikely event of a large oil spill into the fjord, the eagles could be directly affected because they catch fish from the fjords, especially while rearing young. They would also be affected if a chemical or oil spill caused the loss of a salmon run or other food organisms. Any major reduction of herring populations or other prey organisms could cause a decrease in reproductive success.

Mountain goats are reported to be relatively susceptible to impacts of development. Chadwick (1973 cited by Smith and Raedeke 1983) demonstrated that goats may abandon habitat, at least temporarily, as a result of road building activity. As they abandon preferred habitat, they may become vulnerable to predation by bears and wolves (Smith and Raedeke 1983). Smith (1984b) observed a trend of apparent change in mountain goat distribution in the K-4 (Quartz Hill) area, which coincides with timing of the exploration, baseline site studies, and bulk sampling for the Quartz Hill project. The trend observed is illustrated in Table 4-16. It shows that the Falsegate Creek drainage, representing approximately the southern half of the K-4 survey area, has contained an increasing proportion of the goats observed in the annual surveys conducted in August or September. The Falsegate drainage had about 20 percent of the goats in 1973 and 1975 and about 60 percent in 1982. The obvious conclusion is that the goats have responded to the increased activity and noise in the northern part of the K-4 area by moving to the more southerly ridges. If this conclusion is correct, then a similar response may be expected during project construction and operation.

Noise effects, as discussed by Dufour (1980), are presumed to be a major component of goat responses to human activities. Unpredictable noises were reported to be especially likely to evoke a response from large mammals. Helicopters have been extremely important in the exploration, development, and baseline study of the Quartz Hill project, and they are both loud and unpredictable. Harrison et al. (1980) report helicopter noise levels of about 102 decibels at 50 ft, which would attenuate to 78 decibels at 800 ft, a level loud enough to cause the commonly observed fleeing response by mountain goats. Blasting noise is another intermittent source of potential disturbance. Levels of mining blast noise at key points in goat winter habitat are shown in Figure 4-20 along with operational noise levels.

If the level of mountain goat disturbance during construction and preproduction phases of the project is assumed to be similar to that of the exploration, baseline study, and bulk sampling phases, there would be projected impacts to the mountain goat population resulting from construction and preproduction activities. If the change of mountain

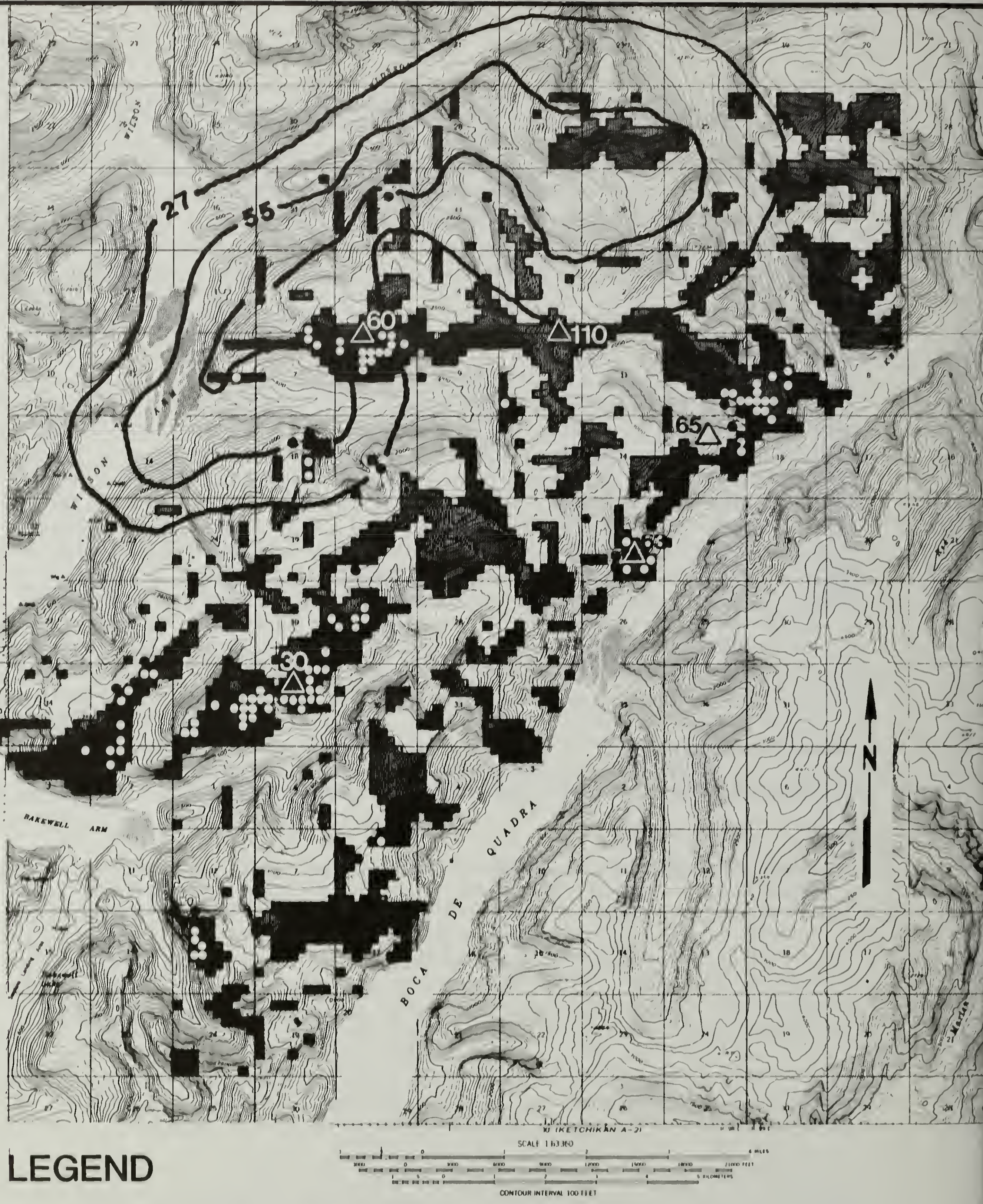
TABLE 4-16

RESULTS OF COMPLETE SURVEYS OF K-4
1973-1982 WITH BREAKDOWN OF GOATS
OBSERVED IN FALSEGATE CREEK DRAINAGE

Year	Goats Observed	Survey Time (hr)	Falsegate Creek Drainage		
			Percent of Adults	Percent of Kids	Percent of Total
1973	103	1.08	18.9	23.1	19.4
1975	18	0.78	26.7	0.0 1/	22.2
1976	25	0.95	27.8	14.3	33.3
1977	58	0.93	30.8	42.1	34.5
1978	84	0.85	47.7	52.6	48.8
1979	60	1.08	45.5	50.0	46.7
1981	95	0.75	51.5	44.4	49.5
1982	87	1.03	57.5	60.9	59.8
$\bar{x}$	66	0.81	38.3	41.1	39.3
S.E.	11	0.04	4.9	6.3	5.0
n	8	8	8	7	8

1/ Value deleted from calculations due to small sample size (kids = 3).

SOURCE: Smith 1984b.



LEGEND

Note: "Indistinguishable" noise level for humans is about 27 dBA here.

Relocations of radio-collared goats, from Nov. 1982 to Mar. 1983.

Preliminary prediction of mountain goat winter habitat.

— 55 — Operational noise levels (L_{eq}) in dBA.

60△ Mining blast noise levels at key points.

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

PREDICTED GOAT WINTER HABITAT AND PROJECTED NOISE LEVELS

SOURCE SMITH (1983) b DATE MAR 84

FIGURE 4-20

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

goat distribution in the K-4 area shown in Table 4-16 is maintained, the northern part of the area will have about 40 percent, rather than 80 percent, of the population, or about half its expected production of goats. Even at 1982 population levels (see Table 3-13), this could mean up to 60 fewer goats in the area than expected, and the population is still growing. Differences of this order of magnitude would only be realized, however, when the adjacent areas approach their carrying capacity. At the present rate of growth, it is possible that carrying capacities could be approached during the project construction phase.

During the mining phase, the power plant, crusher, and concentrator would be operating, and mining activity, including blasting, would be at its peak. Presumably, however, there would be less helicopter activity, and noises would be more regular and predictable than during construction, thus allowing goats to habituate to the noise. Operational activities would continue through the winter, and therefore would have more potential impact on the goats concentrated on the winter habitat as shown in Figure 4-20. The project facilities and activities would probably interfere with the limited amount of goat migration that now occurs across the Beaver Creek-White Creek valleys. Overall, the impacts on the mountain goat population would probably be of the same order of magnitude for both construction and mining phases.

With several hundred people working in the project area, some are likely to hunt mountain goats, legally or illegally. Hunting regulations, including permit systems, bag limits, and closures, would probably become more restrictive to compensate for this effect. Hunter harvest, poaching, and harassment of goats are likely to increase goat mortality. Harassment may disperse some goats to marginal habitat, increasing their vulnerability to mortality, especially during severe winters or during the rut or at the time when kids are born. Without specific controls, the effects of opening the area to access by many people could have a significant impact on the goat population as it did for the population reported on by Phelps et al. (1975).

Direct reduction of heavily used goat habitat would be too small to be significant. About 200 ac of subalpine meadow habitat would be lost in the mine pit and waste rock areas, but most of it is not near enough to escape terrain to be important to the goat population. The indirect impact of an SO_2-caused reduction of mosses and lichens on the trees along the north side of Tunnel Creek appears unlikely and insignificant.

The cumulative effect of all potential impacts on mountain goats would be a reduced population in the project area, to a level below the number that would be there without the project. The reduction could amount to as much as one fourth the potential population.

Black and brown bears would be subject to increased hunting pressure as a result of the proposed project. The brown bear population would probably be more affected by the pressure than would the black bear

population. Black bears especially are attracted to garbage cans (or by being fed) and eventually become nuisances. When the nuisance situation becomes dangerous, the bear must be destroyed. Ultimately, the bear population would be reduced. Several nuisance bears have been killed during the exploration and bulk sampling phases of the project (Wood 1983b). Tietje and Ruff (1983) found that the short-term impacts of oil development on a black bear population were not significant, but they concluded that human interactions were of greatest consequence to bears. Since fewer brown bears occur in the area, the population would be more significantly affected than the black bear population.

Black bears range through the habitats of the project area. The loss or alteration of habitat by the project is expected to be insignificant since a small percentage of habitat would be affected. One area apparently harboring a number of bears (including some brown bears) is the area adjacent to the Wilson River estuary, including the lower part of the Tunnel Creek valley (VTN 1982d). The development in Tunnel Creek would affect cover used by several bears, possibly including denning sites. If a major oil spill occurred near the Wilson estuary, important spring bear habitat would be effectively lost for at least one season and possibly reduced in value (for bear grazing) for several seasons. If an oil or chemical spill caused the loss of a major salmon run, bears would be affected, especially those that tend to rely on fish for part of the year. The effect would be especially important if the berry crop or other food supplies were simultaneously low.

As wildlife becomes more rare in an area, it becomes more valuable and expensive to replace. The Wilson/Blossom brown bear population, as a case in point, would become particularly vulnerable as losses occur. Considering their low fecundity, as brown bears are removed from the area the entire Wilson/Blossom population may come into jeopardy if mortality exceeds recruitment. As brown bears are removed, the remaining bears become more valuable and experience a greater vulnerability.

Furbearer populations would probably be reduced, especially along the Wilson estuary and lower Wilson River, because of the roads interfering with use of adjacent habitat because of dust, noise, etc. and potentially because of increased trapping. Traffic on the roads could also cause some direct mortality of any wildlife species crossing the road.

The improved access and visibility of waterfowl and deer in the project area to the project personnel suggest hunting would increase. Deer populations currently are low, and it may be several years before they become important in the project area (Smith 1983b). Waterfowl use of the Wilson and Bakewell estuaries would probably decrease with increased hunting pressure. Trapping of furbearers, especially marten, mink, and otter, may also increase because of improved access, and populations would decline.

Increased boat and aircraft traffic, as well as project noise (see Figure 4-20) and the increased activity at Wilson wharf and along the access road would disturb waterfowl using the Wilson estuary. It also may disturb harbor seals at estuarine haulout areas and at Seal Rock near Bakewell Arm. The result would be decreased seal and waterfowl use of the estuary, especially the east half nearest the road and wharf. An oil or chemical spill in the estuary or fjord would affect all wildlife species that use these areas (e.g., marine mammals, marine birds, waterfowl, shorebirds, furbearers, bears) directly by toxic effects and indirectly by loss of food organisms (see Appendix G, Section 14). Effects of tailings constituent toxicity and bioaccumulation on wildlife are expected to be insignificant (see Appendix G, Section 12).

Impacts from all other components and activities of the project, including the water supply reservoirs and water quality control ponds, are considered individually insignificant, but they add to the cumulative effect of the project.

4.2.4.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

Construction of the town at the Bakewell site could affect two eagle nests (FWS 15 and FWS 16; see Figure 3-38) because they would be within 0.5 mi of construction activities. Nest FWS 16 was actively used in 1982, but FWS 15 was only a remnant of a nest and remained unused. If an access road between the Bakewell townsite and the Wilson Arm wharf is built, two additional nests would be affected: nest FWS 14 at the mouth of Falsegate Creek and nest FWS 6 on Wilson Arm's east shoreline were inactive in 1982 (VTN 1982d, Appendix F). The road could presumably pass within 330 ft of each nest, requiring a variance from the U.S. Fish and Wildlife Service. Impacts could be significant if the nests are being used. If the town is constructed at the Wilson I or IIa sites, no additional eagle nests would be affected.

Any of the three townsites would provide another focal point for attraction of nuisance bears and would also have the effect of placing the leisure time of the residents in the midst of hunting and trapping opportunities. The commute time that currently isolates the game animals from most hunters would be eliminated, and visitors to the town would also add to the hunting pressure. The resulting legal and illegal hunting and incidental harassment would surely be the most significant impact on wildlife (especially mountain goats, bears, waterfowl, and furbearers) of any of the project components.

The incremental loss of wildlife habitat would also be relatively important because the townsite locations are at low elevations near estuarine habitat. The Wilson IIa townsite would provide access to the west side of the Wilson estuary and thus expose wildlife on both sides of the estuary to harassment. The Bakewell site with the access road would seriously reduce the value of the Bakewell estuary to wildlife. The Wilson I site would affect lower Wilson and Blossom river wildlife habitat.

Development of any townsite in the project area would cause significant impacts to wildlife. Probably the least impact of the three sites would result from a town at Wilson I.

If a tailings tunnel is driven directly to the middle basin of Boca de Quadra, the potential impact on bald eagles using nest number FWS 11 would be eliminated. All other impacts on wildlife would be the same as described in Section 4.2.4.2. The suboption of extending the tailings pipeline from the tunnel portal in the inner basin to the middle basin would have little effect on wildlife.

4.2.4.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

Effects of this alternative would be very similar to those described in Section 4.2.4.2. This alternative would keep the tailings disposal within the same fjord basin as the access road and eliminate the impacts on the Boca de Quadra system, including the two eagle nest locations at the tunnel portal.

4.2.4.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

This alternative would consolidate the effects of mining and milling operations into a small area and eliminate the effects in the Tunnel Creek valley. However, if the power plant is located in the Tunnel Creek valley, the impacts on wildlife would be similar to those described in Section 4.2.4.2. The bear and mountain goat habitat lost because of the Raspberry Creek reservoir and along the tailings pipeline corridor constitute an insignificant percentage (a fraction of a percent) of the habitat available in the area. The construction of the tailings tunnel portal and pipeline above the Keta estuary and along the fjord would disrupt important habitat for bears and eagles. These impacts would be removed if the tailings tunnel is built directly to the discharge point in the inner basin. If the pipeline ruptures, the spilled tailings would make the inundated habitat less productive for a few years. This would be especially important at the Keta estuary.

4.2.4.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

The effects of this alternative are similar to those of Wilson Arm tailings disposal from the Tunnel Creek mill but without the impacts on the Tunnel Creek valley. The main difference is the greater access road width required to accommodate the tailings pipeline from the mill at Beaver Creek to the Wilson Arm wharf. Wildlife movements may be somewhat restricted by the pipeline, depending upon whether it is constructed to minimize obstructions to passage.

4.2.4.7 Beaver Creek Mill with On-Land Tailings Disposal

On-land tailings disposal would double the loss of wildlife habitat, and additional habitat would be subject to construction disturbance that would extend over many years. Both Tunnel and Aronitz creek valleys are at the edge of estuaries and, therefore, habitat of greatest value would be subject to long-term disturbance.

Four eagle nest trees would be affected by construction of the pipeline to Aronitz Creek and construction of the dam (see Figure 3-28).

4.2.4.8 North Meadow Mill with Boca de Quadra Tailings Disposal

The impacts on wildlife from the main components of this alternative would be similar to those described in Section 4.2.4.2. There would be no impacts in the Wilson Arm drainage; rather, construction and operational impacts would affect the Keta drainage. Six eagle nest trees along the Keta River and Aronitz Creek mouth would be affected by this alternative. Disturbance of both sides of the Keta estuary would cause a substantial reduction in wildlife usage of this important habitat. The water reservoir in Hill Creek would remove about 40 ac of bear and goat habitat. Impacts of a townsite at the head of Boca de Quadra would be similar to those of other townsite alternatives.

4.2.4.9 North Meadow Mill with On-Land Tailings Disposal

No new impacts would be introduced by this alternative.

4.2.5 Threatened and Endangered Species

The proposed project and the alternative concepts will not affect any threatened or endangered species. This conclusion is documented by consultation under Section 7 of the Endangered Species Act with the U.S. Fish and Wildlife Service (Nelson 1983) and informal consultation under Section 7 with the National Marine Fisheries Service (McVey 1983).

4.3 CONSEQUENCES ON THE SOCIAL AND ECONOMIC ENVIRONMENT

4.3.1 Socioeconomics

4.3.1.1 No Action

The no action alternative is treated synonymously with the baseline conditions, which are discussed in each subsection. While there may be economic opportunities foregone from not developing the project, these have not been treated as impacts.

4.3.1.2 Proposed Project

The proposed project would involve two distinct construction periods and the operations period. The operations period would overlap the construction periods. The impact analysis is based on a construction and operation schedule that was formerly proposed by U.S. Borax. That schedule included construction beginning in 1985 (project year -4), mine startup at 40,000 tpd in 1989 (project year 1), and expansion to 80,000 tpd in 1993 (project year 5). Project-related impacts were estimated by adding the project-induced population and employment figures to the baseline, without-project figures for the same year. Thus, the total estimated 1985 population would be equal to the projected baseline population in 1985 plus the project-related population in the first year of construction (project year -4).

Although the 1985 construction start has been delayed, a new schedule has not been proposed. Figures in Section 4.3.1 are therefore still based on the original schedule. U.S. Borax has made a commitment to reestimate project impacts using a revised population/employment baseline before construction begins. The first construction period, occurring from year -4 to year 1, would result in development of the mine, mill, and ancillary facilities for an initial 40,000 tpd level of operations. The operations period would initially include the preoperations preparations for project startup. This preoperations phase would last two years. The operation phase would commence in year 1 and continue throughout the life of the mine. The second construction period, from year 3 to year 5, would prepare the facilities for an 80,000 tpd production level. Although this construction schedule has been delayed, a new schedule has not been set.

Work schedules would vary for each phase of the project. The work schedule for the construction periods would be set by the individual contractors. It is expected that construction people would work long hours with little time off. Construction workers would live in construction camps at Quartz Hill. On every weekday, U.S. Borax would transport up to 200 workers to Ketchikan for the day. U.S. Borax plans to have a construction staff family housing camp with about 40 units, although the construction staff would have the option of locating their families at Quartz Hill or Ketchikan. During the operations period, the work schedule would be 7 days on, 7 days off for most workers. However, office personnel and most management and engineering personnel would work a 40-hour week. The 40-hour-a-week employees would be transported to and from Ketchikan on Friday afternoon and Monday morning. It is assumed that the families of married operations personnel would accompany them and settle in Ketchikan. Since the operations workers would be based in Ketchikan, the proposed project is referred to as the commute option.

Some personnel hired for construction could be hired into the permanent operations work force. This would probably be found among the laborers rather than among the managerial staff, skilled craftsmen, and semiskilled craftsmen. The possible continued employment among the laborers was taken into account in assuming that 10 percent of the construction work force would bring families to Ketchikan.

The impact projections for employment, population, housing, and public services and facilities are based on a set of assumptions regarding the characteristics of the in-migrating work force and the extent to which local residents obtain work associated with Quartz Hill. These assumptions are discussed in Appendix I, the technical appendix on socioeconomic impacts. Due to the assumptive nature involved in predicting events, there is a degree of uncertainty to the quantification of impacts presented in this section. The impacts can be reevaluated at various stages of Quartz Hill development by monitoring the actual changes resulting from the project.

The impact projections are based on the schedule as presented above and the impacts represent the difference between the with-Quartz Hill and without-Quartz Hill (also referred to as baseline) conditions. A delay

in project construction and startup would have some effect on the impact projections because the with-Quartz Hill conditions would be compared to different baseline years. It is likely that the effect would be fewer rather than greater impacts since population growth under baseline conditions would result in a small project-related population impact over time.

Employment

Employment related to the Quartz Hill project would consist of both direct and indirect employment. Direct employment would include Quartz Hill employees working on construction and operations at the mine site and at the U.S. Borax office in Ketchikan. The construction work forces would increase and decrease at a relatively high rate. The first construction period would reach a peak work force of 1,180 at the end of 1987. The peak work force during the second construction phase would reach 300 persons. Unlike the construction work forces, the operations work force would build up rapidly from year -2 to year 2 to 710 workers and then gradually increase to 910 workers over the next 10 years. The Ketchikan office personnel would increase from 10 persons in year 3 to 80 persons in year 1 and stabilize at that point.

Indirect employment would involve persons working in the construction, trade, services, and government jobs that would be created as a result of the Quartz Hill project. During the construction period it was estimated that for every 100 jobs on Quartz Hill there would be 25 support jobs created. The number of jobs created as a spinoff of the Quartz Hill project during the operations period would be 70 for every 100 jobs at Quartz Hill.

A source of indirect employment, in addition to the new secondary jobs created, would be the job openings resulting from presently employed local people taking jobs on the Quartz Hill project. These vacated positions would become available to other unemployed and underemployed residents. However, vacated jobs not filled by local residents would be filled by newcomers to the area. Therefore, local hire on the Quartz Hill project would trigger an upward shift in employment locally and attract new people to the Ketchikan Gateway Borough. A secondary effect of the upward shift in employment would be the loss of trained personnel, resulting in training for the new hires and possible temporary loss of productivity. On this assumption, approximately 30 vacated jobs would be filled for every 100 jobs on Quartz Hill.

In year 2, the Quartz Hill project would directly employ approximately 800 persons and result in indirect employment of about 800 additional persons. By the year 2000, direct and indirect employment would increase to approximately 1,000 persons each. Thus, the Quartz Hill project would result in a long-term employment effect of approximately 2,000 persons.

The distribution of employment benefits between the local and nonlocal populations is presented in Table 4-17. Because of the limited local labor pool, the project would attract a large number of outsiders, including other Alaskans and residents of other states. The overall proportion of nonlocal to local employment would be approximately 2.3:1.

TABLE 4-17

DIRECT AND INDIRECT JOBS CREATED
BY CONSTRUCTION AND OPERATIONS OF THE QUARTZ HILL PROJECT

Project Year	Local			Nonlocal			Grand Total
	Direct	Indirect	Local Total	Direct	Indirect	Nonlocal Total	
-4	8	8	16	72	19	91	107
-3	51	53	104	440	123	563	667
-2	148	152	300	1,134	355	1,489	1,789
-1	137	136	273	414	315	729	1,002
1	213	209	422	498	488	986	1,408
2	237	232	469	554	543	1,097	1,566
3	239	234	473	572	548	1,120	1,593
4	289	284	573	782	664	1,446	2,019
5	294	288	582	686	672	1,358	1,940
6	294	288	582	686	672	1,358	1,940
7	297	291	588	694	681	1,375	1,963
8	294	288	582	686	672	1,358	1,940
9	294	288	582	686	672	1,358	1,940
10	297	291	588	694	681	1,375	1,963
11	297	291	588	694	681	1,375	1,963
12	297	291	588	694	681	1,375	1,963

For the construction period, two scenarios for the portion of local hires in the work force were evaluated. A comparison of the 35 percent and 10 percent local hire assumptions indicates that in the fourth quarter of year -2, which is the peak construction period, the total number of jobs filled by local residents would be 650 and 300, respectively. These local employment projections include the effects of local people leaving their present jobs for positions at Quartz Hill due to the attractiveness of the Quartz Hill jobs. A portion of their vacated positions would, in turn, be filled by other local residents. This upward shift in jobs and opening up of the local job market could benefit a portion of the underemployed and unemployed population. The total number of permanent jobs created as a result of the project would be no different for the 35 percent or 10 percent local hire scenarios because this scenario affects only the construction phase.

In comparing the with-project employment forecasts to baseline employment forecasts, the growth in jobs would be accelerated by 13 years. The number of jobs in year 12 under baseline conditions would be approached in year -2 with the commute option.

Personal Income

The economy of the Ketchikan Gateway Borough and of the region would benefit from the spending of wages by the direct and secondary workers. The wages of construction workers were not included in the estimate of total personal income since these workers would spend most of their time at the project site and have relatively few opportunities to spend their income in Ketchikan. The wages associated with persons filling vacated jobs were not included as these jobs are part of the baseline employment.

When the operation of the mine begins in year 1, $29.2 million in direct personal income would be generated. An additional $13.4 million would be generated through the wages and salaries of secondary workers. Between year 2 and year 17, Quartz Hill direct and secondary income would average $36 million and $18 million a year, respectively. Throughout the 16-year period, direct and secondary wages and salaries would total approximately $569 million and $292 million, respectively, for an estimated total personal income of $861 million. The annual estimates of direct and secondary personal income are presented in Table 4-18.

The relative impact of new personal income generated by the Quartz Hill project would represent a significant increase over baseline conditions. Personal income due to the proposed project would be approximately 19 percent of the total personal income generated in the Ketchikan Gateway Borough in year 2, increasing to 21 percent in year 12.

Local and Regional Business Activity

The population increase in the Ketchikan Gateway Borough would generate an increase in volume of new business for area firms. Local businesses would expand their inventories to supply goods and services directly to Quartz Hill and/or to serve the needs of additional new residents.

TABLE 4-18

PROJECTED PERSONAL INCOME DUE TO OPERATION
OF QUARTZ HILL, KETCHIKAN GATEWAY BOROUGH
(thousands of constant 1984 dollars)

Project Year	Direct1/	Secondary2/	Total
-4	-	540	540
-3	370	3,429	3,799
-2	3,700	9,855	13,555
-1	15,170	8,694	23,864
1	29,230	13,419	42,649
2	29,230	14,931	44,161
3	29,230	15,066	44,296
4	33,670	18,279	51,949
5	36,260	18,522	54,782
6	36,260	18,522	54,782
7	36,630	18,711	55,341
8	36,260	18,522	54,782
9	36,260	18,522	54,782
10	36,630	18,711	55,341
11	36,630	18,711	55,341
12	36,630	18,711	55,341
13	36,630	18,711	55,341
14	37,000	18,900	55,900
15	37,000	18,900	55,900
16	37,000	18,900	55,900
17	37,370	19,089	56,459

1/ Based on an average annual salary of $37,000.
860,398/16 = 53,775 (16 yr avg).

2/ Based on an average annual salary of $27,000.

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Four types of effects could occur in the trade and services sector. First, the Quartz Hill project would have the positive long-term benefit of increasing the revenues for firms due to an increase in demand for goods and services. Secondly, at the same time, however, costs in the short-term would likely increase due to the added costs of labor, taxes, larger inventories, and expanded floor space. In fact, the prices of the locally purchased goods and services could increase substantially as businesses try to offset their rising costs. However, the higher volume and increased competition could benefit Ketchikan residents as there could be reduced costs for many goods and services over the long-run. A third effect would be an increase in business activity that could lead to an influx of new business establishments, including chain stores. The likelihood of this impact is uncertain as case studies of rapid growth areas provide little evidence that these changes occur (Leistritz et al. 1982, p. 46). The fourth type of impact on businesses would be related to any uncertainty about timing of construction and operations of Quartz Hill and molybdenum production levels, which would affect their ability to deliver specific goods and services. This uncertainty would also affect the ability of businesses to make investment decisions about new or expanded facilities or expanded inventories.

Project Effect on the Value of the Commercial Fishery

Construction and operation of the Quartz Hill project would have an effect on the fish and shellfish population of Boca de Quadra basins, Wilson Arm, and some area streams. These areas contribute to the fishery resources in Ketchikan Fisheries Management Districts 1-4. The effects vary by alternative, particularly because alternative tailings disposal plans affect different fish and shellfish habitats. The loss or degradation of fish habitat, and its effect on fish and shellfish populations, is discussed in Section 4.2. Detailed calculations and assumptions are outlined in Appendix G.

A reduction in the fish and shellfish population can have an impact on the commercial fishing industry. Estimates have therefore been made of the possible impact (Appendix G, Section 18). The estimates are based on average exvessel prices for the 1980 through 1982 fishing seasons (Appendix G, Table 18-1). In the absence of mitigation measures, the maximum estimated impact on the commercial fishing industry in Ketchikan Fisheries Management Districts 1-4 is between $5,000 and $45,000 per year, depending on the alternative chosen (Appendix G, Table 18-2). The higher losses are associated with the on-land tailings disposal options, because they obliterate segments of some salmon streams. The lower losses are associated with tailings disposal methods that have only moderate impacts on salmon, bottomfish, and shellfish. The Tunnel Creek mill/Wilson Arm tailings disposal alternative could reduce the value of the fishery by about $7,000 per year. This estimate assumes that commercial fishermen in Districts 1-4 would spend as much time and money during the season as before the project, but for a reduced catch, or that they would spend more time and money to produce the same average catch as before the project.

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The Tunnel Creek mill/Wilson Arm tailings disposal alternative could reduce the annual salmon harvest by an average of approximately 1,665 fish per year (Appendix G, Tables 17-1 and 18-1). The total salmon harvest for Ketchikan Fisheries Management Districts 1-4 has been estimated at over 10.2 million fish per year (Table 3-10). The loss due to the project is therefore expected to be a negligible proportion of the total.

The total value of the Boca de Quadra and Smeaton Bay shrimp and dungeness crab industry was estimated at approximately $64,000 in 1982 (Appendix G, Table 7-2), or $69,000 in 1984 dollars. The shellfish loss associated with the Tunnel Creek mill/Wilson Arm tailings disposal alternative is valued at $2,678 (Appendix G, Table 18-2), or about 4 percent of the area shellfish value.

Population

Population growth due to Quartz Hill would represent a 3.9 percent average annual increase during the year -4 to year 2 period, 1.7 percent during the year 2 to year 7 period, and 0.9 percent during the year 7 to year 17 period. This compares to average annual growth rates of 1.2 percent, 1.2 percent, and 1.1 percent under baseline conditions for those three periods, respectively. By contrast, the rapid population growth experienced in energy and mining boom towns of the Rocky Mountain states has typically been in excess of 10 percent per year. Project-related growth compared to baseline growth is presented in Table 4-19.

The most rapid period of project-induced population growth would occur between years -3 and -1, when the number of new residents would increase from 120 to 1,300. Population would decrease during year -1 and climb back to its previous level by year 2, reflecting the downside of construction and the subsequent buildup in operations. Between year 2 and year 20, a period of 18 years, project-induced population would increase from about 2,200 to 2,800, which is due primarily to an increase in operations and secondary employment. The ultimate project-induced population would reach about 2,800 persons in year 20. Total population at that time, including growth in the baseline population, would be about 21,600 compared to 18,800 without Quartz Hill.

In comparing the with-Quartz Hill population projections to the baseline population projections, the estimates indicate that the project would accelerate population growth by about 11 years. The baseline population of 18,759 in year 15 is comparable to the with Quartz Hill population in year 4. If the effects of the presence of speculative in-migrants or unsuccessful job seekers are taken into account, the project would accelerate growth by an additional year. The speculative in-migrant population has not been included as part of the permanent population base because it is assumed that transients who are not able to find a job would leave Ketchikan eventually. For the purposes of estimating service and facility requirements, the

TABLE 4-19

POPULATION IMPACTS

COMMUTE OPTION

Project Year	Baseline	Baseline and Quartz Hill (excluding speculative in-migrants)	Baseline and Quartz Hill (including speculative in-migrants)
-4	14,920	14,968	15,065
2	15,900	18,087	18,425
7	16,944	19,685	20,109
12	18,057	20,797	21,221
17	18,759	21,555	21,987

speculative in-migrant population was taken into account in projecting impacts on social and health services. For the other services and facilities, it is prudent to plan for only the permanent residents.

Operations workers from outside the Ketchikan area who are attracted by the project could decide to move to Prince of Wales Island rather than to the Ketchikan Gateway Borough. Other operations workers could commute from Seattle. Unsuccessful job seekers could decide to relocate to other areas of southeast Alaska rather than move back to their place of origin. Communities in the vicinity of Ketchikan, such as Craig and Hydaburg, have a limited economic base and a lack of job opportunities that would deter the movement of in-migrating Quartz Hill job seekers to those communities. While some impact on regional population can be expected, it cannot be quantified.

Housing and Land Use

As a result of the population influx, about 800 housing units would be required between year -4 and year 2. After year 2, an additional 200 housing units would be required over the next 18 years. The housing requirements by type of unit are presented in Table 4-20. Information on the expected breakdown by housing type was provided by the Ketchikan Gateway Borough Planning Department. The designation of housing type is based on the assumption that more multifamily housing would be required during the construction phase and in the initial years of the operations phase than in later years. The number of housing starts required each year are also shown in Table 4-20.

TABLE 4-20

HOUSING REQUIREMENTS DUE TO QUARTZ HILL PROJECT
BY TYPE OF UNIT
(Number of Units)

Project Year	Single Family	Multifamily	Mobile Home	Total	New Units Required
-4	10	0	7	17	17
-3	67	33	11	111	94
-2	208	104	35	347	236
-1	259	130	43	432	85
1	418	209	70	697	265
2 (5 years)	504	194	78	776	79
7 (5 years)	632	243	97	972	196
12 (8 years)	632	243	97	972	0
20	650	250	100	1000	28

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Table 4-21 presents the number of new housing units that would be needed to meet the demands of baseline growth, the number of units attributable to Quartz Hill, and the percentage of housing growth attributable to Quartz Hill. During the year -4 to year 2 period of rapid housing growth, about 55 percent of the total growth would be due to the demand for housing by persons associated either directly or indirectly with Quartz Hill.

Most of the housing impacts would occur during the year -4 to year 2 period, stemming from the need to construct a large number of units in a short time. Miscalculations of the type of housing that would be demanded by the in-migrating population could be made. Construction of the wrong type of housing units could cause overbuilding of some units and shortages of others. The location of the new housing units is another factor that would influence potential buyers. Selection of an undesirable location by a housing developer could cause a mismatch of supply and demand. Data obtained through case studies of energy impacted communities in the Rocky Mountain states indicate a disparity between the type of housing preferred and actually selected by construction workers (EPRI 1982, p. VII-2). While it is expected that 10 percent or less of the construction workers would bring families to Ketchikan, it could be a sufficiently significant number to affect this gap between preferences and choice.

Land speculation by outside investors could be an adverse impact because of the leakage of income that would result as these developers take their profits out of the Ketchikan area. Outside investors could also have less commitment to quality construction as they might not be interested in developing a favorable reputation locally.

Poor quality and substandard construction could occur during this period of rapid housing starts. This could be a problem, particularly outside city limits where there is no building code. There could be an abundance of mobile homes, which could be preferred by construction worker families. A mobile home park consists only of streets, concrete pads, and utility hookups and can be developed more rapidly and economically than a subdivision of single family dwellings. Depending on their location and density, mobile homes could create problems for the provision of sewer, water, and fire protection services since there are limited public services outside city limits (Morehouse and Associates 1983, p. 25).

During this year -4 to year 2 period, a shortage of housing could result in a demand for temporary housing, including hotels, motels, and rooming houses. Individuals and families could also bring travel campers and boats for their housing. Secondary impacts could result from the housing shortage. The use of temporary housing by the in-migrating population could have an adverse effect on tourism. The crowded conditions of Ketchikan could make the community less desirable for tourists, resulting in fewer ports of call. The housing shortage would also result in increases in rents and housing prices, which would

TABLE 4-21

COMPARISON OF HOUSING REQUIREMENTS
BASELINE AND WITH QUARTZ HILL
COMMUTE OPTION
(Number of Units)

Project Year	Baseline	Quartz Hill	Baseline and Quartz Hill	Percentage of Growth Attributed to Quartz Hill
-4	67	17	84	20
-3	68	94	162	58
-2	68	236	304	78
-1	70	85	155	55
1	70	265	335	79
2 (5 years)	71	79	150	53
7 (5 years)	371	196	567	35
12 (8 years)	394	0	394	0
20	249	28	277	10

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adversely affect people with fixed and low incomes. A third secondary impact of the housing shortage, combined with inflated housing prices, could be difficulty in recruiting well-qualified persons to fill local positions.

Front-end financing by the developer and financing home purchases by the buyer are two risks involved in developing the large number of housing units required by the in-migrating population. From the standpoint of the housing developer, uncertainty about the timing of project development could contribute to inflated housing prices. A slippage in the construction schedule by U.S. Borax could result in a temporary excess of housing. A shortage of construction labor could force wages to increase. As a result, housing developers could have to pay high prices for possibly low quality workmanship. Faulty construction and high labor turnover rates could result in housing construction delays. From the buyer's perspective, he/she could be reluctant to invest in a house under inflationary conditions.

Housing developers could benefit local banks by obtaining financing for Ketchikan's housing needs. The potential financing problems for all concerned parties, including the lender, housing developer, and buyer, explain part of the popularity of mobile homes (EPRI 1982, p. VII-4).

The improvement costs for water, sewer, and streets associated with development vary with topography. Land availability would not be a constraint to housing, although the costs of lots could increase as more marginal lots on steep slopes are developed. In 1983 there were 1,744 vacant lots on private property in the KGB, with 500 located inside city limits (KGB 1983a, p. 31). These lots are platted but do not necessarily have road access or improvements. The pressure to build multifamily units and subdivisions would occur on land inside or on the periphery of the city that could be subsequently annexed by the city to take advantage of the city services. The lack of adequate water supply outside city limits would be the major constraint to large-scale housing, commercial, or institutional development. The limitations of borough services would be an additional constraint to development. Education, planning and zoning, and animal control are the only public services directly provided by the borough. Fire protection, emergency medical services, and some water supplies are provided by service districts. Electricity and telephone are provided by extensions from the Ketchikan Public Utility system.

Public Service and Facilities

The public services and facilities in Ketchikan, Saxman, and the borough are at various stages of capacity. Each service and facility can be categorized into one of the following three groups: (1) services and facilities at or beyond capacity taking into account planned expansions; (2) services and facilities that can meet current demand but would need to expand as population grows; and (3) services and facilities that have excess capacity and would be able to accommodate future growth.

Services and facilities that fall within the first category would be most impacted by future growth. Those services and facilities currently operating at, or in excess of, capacity include recreation, schools, social services (includes mental health services), landfill for solid waste disposal, ports and harbors, library, museum, and roads. These systems are currently being impacted by the existing population and additional growth would exacerbate the problem. Since the existing inadequacies cannot be attributed to Quartz Hill, it would be important to bring those services and facilities to appropriate levels before population growth from Quartz Hill occurs.

The services and facilities within the second category would also need to be expanded regardless of whether Quartz Hill is developed. The additional population growth attributable to Quartz Hill, however, would alter the timing and magnitude of the expansions required compared to baseline conditions. Services and facilities that come under this category are fire protection, law enforcement, sanitation collection, wastewater collection system, streets, water supply, and medical services other than the hospital.

The services and facilities that come under the third category and would be able to accommodate future growth are solid waste disposal (other than landfill), wastewater disposal, telephone system, electrical energy, and the hospital. The status of the wastewater disposal system is dependent upon receiving variances from the Environmental Protection Agency (EPA) for the treatment systems and the extent to which it would need to serve new areas annexed by the city. It has been estimated that the demands of the population both with and without Quartz Hill can be accommodated for 20 years into the future with the existing facilities.

In estimating the impacts of the Quartz Hill project on services and facilities, the appropriate planning horizons were taken into account. For example, in planning for the needs of the project-induced population, a 20-year planning period was used in estimating the need for additional sewage treatment capacity, in contrast to a 10-year planning period for schools. The immediacy of the need for additional capacity was also taken into account, as with the road system.

Water Supply - The population within the city limits of Ketchikan is served by a gravity water system operated by the Ketchikan Public Utilities. The average daily water demand at 500 gallons per capita per day is unusually high (KGB 1983a, p. 85). This high water consumption rate is caused by line loss in the wood stave pipes and the shallow depth of the water pipes in certain areas of town, which causes people to keep water running during the winter to prevent pipe freezing. The city's untreated water supply has a capacity of approximately 11 to 12 million gallons per day (mgd) (Brostrom 1984). It has been estimated that Ketchikan has an adequate potable water supply without improvements to the system through 1995. The water system would be adequate for a much longer period if improvements were

made to the distribution system pipelines by replacing leaky pipes and burying pipes deeper to prevent the likelihood of winter freezeup. Alternatives for increasing water supply include increasing the capacity of Carlanna Dam, diversion of a portion of Ketchikan Lake's hydroelectric water for potable use, and locating a new water source (KGB 1983a, p. 85).

Outside of Ketchikan, individual water systems rely upon roof catchment and storage systems and, in a few cases, streams and wells. The City of Saxman has an independent water supply and distribution system as does the Mountain Point Service District. The lack of surface water and adequate aquifers poses a constraint to development, particularly multifamily housing, commercial, and institutional development because roof catchment systems cannot supply the water demand. In the absence of surface impoundment of water, development would occur in or adjacent to city limits where water is available. The most significant impact of the water supply situation with the commute option would be the land use effects in which development would follow water and sewer pipes.

Wastewater Disposal - A sewage collection system serves developed portions of the city and discharges untreated wastes by gravity outfall into Tongass Narrows. Peak sewage flows in the winter are twice the volume of peak flows in the summer due to winter water waste. An interceptor system and seven pump stations were recently completed to move all sewage to one location where a wastewater treatment system is planned. This plant, which is funded 75 percent by the Environmental Protection Agency, 12.5 percent by the Alaska Department of Environmental Conservation, and 12.5 percent by city bond funds, would involve minimal wastewater treatment, including fine mesh screening and a deep water diffuser. The plant has been designed to handle a peak flow of 5.9 mgd to serve a population of 13,370. The expected completion date for the plant is January 1986 (Pearson 1984).

Outside of the city limits, sewage is disposed through on-site waste disposal systems and ocean outfall. The City of Saxman, the Coast Guard base, the airport, the pulp company, and four subdivisions have individual sewage collection and treatment systems. Since no sewage collection and treatment systems are provided in the rural residential areas of the borough, surface water pollution is a growing problem. Fecal coliform levels of over 500/100 milliliters (ml) have been found in 16 streams north and south of town, during a survey conducted in 1983. This compares with a finding of no streams of fecal coliform count greater than 500/100 ml during a survey conducted in 1974. The adverse effects of water pollution include risk to health, nuisance of smell, and difficulties in obtaining home mortgage loans (KGB 1983a, p. 85).

Within the city limits the wastewater treatment plant would have the excess capacity to handle both baseline and with-project populations for at least 20 years. Based on a standard per capita sewage generation rate of 115 gallons per day (Pearson 1984), the treatment requirements for a city population of 13,370 would be 1.5 mgd on the

average and 3.8 mgd at the peak (assuming peak flow equals 2.5 times the average flow). If a program were instituted to reduce winter waste, the per capita sewage generation rate would be considerably lower. With a project-induced population of 2,800 and assuming 80 percent locate within the city limits, the peak generation of that population would be 0.6 mgd. The treatment plant would be able to handle the additional sewage to treat a peak of 4.4 mgd and still have additional capacity.

The Quartz Hill development would necessitate the expansion and upgrading of portions of the wastewater collection system. Partial funding for sewer and water lines can be obtained through Local Improvement Districts (LID) and through state grants. The Alaska Department of Environmental Conservation provides up to 50 percent funding for new sewer and water lines, but does not provide funds for the upgrading of a system. The ADEC grants are obtainable for the expansion of systems to serve existing developments as a first priority and future developments as a second priority. The LID allows for floating a special assessment bond to provide upfront money for the capital investment of water and sewer lines. The housing developers pay the principal and interest on the bond through assessments. This cost is then reflected in the price of the property.

Solid Waste - The city's landfill is presently filled beyond the original projected capacity. The city is in the process of acquiring property in the Ward Cove area to build and operate a new landfill for the disposal of ashes and noncombustibles and an incinerator for combustibles. Although no engineering studies have been conducted to estimate the capacity of the planned landfill, preliminary estimates indicate that these sites would be able to accommodate baseline growth for at least 50 years. Actual construction of the landfill and incinerator is anticipated to occur in 3 to 4 years. The preliminary design for the incinerator has been sized to accommodate 39.6 tons per day of capacity, assuming 24 hours of operation. Based on the planning standard of 4 lbs/day/person of solid waste generation, this incinerator could meet the needs of baseline population of 19,800, which is not expected to occur until after year 2008. Under the commute option, incinerator capacity would be reached in year 9, requiring an additional modular unit at that time. Based on a capital investment of $60,000/ton per day of capacity (1983 dollars), the cost of incineration capacity due to the project-induced population of about 2,800 in year 20 would be about $336,000 (1983 dollars). If the city operates on less than a 24-hour-per-day basis, it may well need an additional incinerator in advance of the projected 1997 date, resulting in a higher cost for additional capacity (Pearson 1984).

The city's solid waste collection division is operating near capacity. The current staff consists of four solid waste collectors (two persons per truck) serving 2,600 commercial and residential accounts. In order to ease the strain on this service, the Department of Public Works requested funds for calendar year 1985 to provide for an additional truck and person who would split work time between street maintenance and solid waste collection.

Based on the local planning standard of 15 accounts/person-hour, it can be estimated that the current staff (including the additional person working full time on solid waste collection) would be able to handle 3,000 accounts or approximately 3,800 households (assuming that a linear relationship exists between number of households and number of accounts). Assuming the distribution of households between city and borough remains the same over time under baseline conditions, this capacity would be exceeded in 1994. The Quartz Hill project would accelerate the need to add staff. In order to plan for the long range needs of the project-induced population of 1,000 households, one additional person would need to be hired. This estimate takes into account a shift in distribution of population residing within the city limits from 64 percent to 80 percent. The cost of hiring an additional sanitation worker, including salary and benefits, would be about $36,400 per year (1983 dollars) (City of Ketchikan 1983).

Street Maintenance - The City Department of Public Works, Streets Division is responsible for maintaining 18.3 mi of streets and 2 mi of wooden walkways and stairways. The staff consists of 18 full-time workers. Assuming that a linear relationship exists between miles of streets to be maintained and staffing requirements, 1 person per mile of street would be the standard used in estimating project impacts (Pearson 1984).

The project-induced population of approximately 2,800 would require four to six additional staff persons. Two alternative methods have been used to calculate impacts. One method is based on the requirement of 60 linear feet of street per lot, which is multiplied by the number of households expected to live inside city limits and in single-family dwellings. This method yields an estimate of six additional miles of streets and, therefore, six additional staff. The second method is based on a ratio of staff person to the number of total housing units and multiplying that ratio by the total number of households expected to live in the city. This estimate yields a requirement of four additional persons. The four to six additional persons would cost from $140,000 to $210,000 per year (1983 dollars) (City of Ketchikan 1983).

The Department of Public Works estimates that one additional street sweeper and one additional sand truck/snowplow would be needed to maintain the additional 6 mi of streets. This equipment would cost a total of $150,000 (1983 dollars) (Pearson 1984). The funding source would be the general fund for the city.

The department would also need to spend additional hours providing engineering and construction inspection for the extension of streets, sewer and water lines, and other public facilities required to accommodate the additional growth within city limits and in new areas annexed by the city.

Telephone - The telephone system, which is operated by Ketchikan Public Utilities, currently provides 6,200 telephone lines to 5,300 business and residential subscribers. The telephone lines are a mixture of private, two-party, and five-party lines. The existing system reached its maximum capacity several years ago. The telephone system recently underwent a massive expansion and replacement project that replaced and upgraded 100 percent of the central switching system and 70 percent of all outside cable plants. The new switching system accommodates 9,614 subscriber telephone lines with capability to serve 13,600 lines (Mood 1984).

Under baseline conditions the expanded telephone system would suffice well beyond 2008, as it is designed to serve a population of 20,000. In order to serve a population greater than 20,000, additional lines would need to be added, but expansion of the central switching system and outside cable plant would not be needed (Mood 1984).

The project-induced population of 1,000 households would require 1,500 lines, based on the planning standard of 1.5 lines per household (Mood 1984). The existing system, once it is expanded, would be able to meet the needs of the Quartz Hill related population until year 7. At that time, new lines would need to be added to the system.

Electrical Energy - The existing generating resources for Ketchikan include thermal and hydroelectric generating plants. Managed and operated by the Ketchikan Public Utilities (KPU), the delivered dependable capacity is estimated to be approximately 12 MW for the diesel resources and 28 MW for the hydro resources, including the Swan Lake project. The combined delivered dependable capacity is 40 MW.

Load forecasts for the KPU service area for the planning period 1982-2002 indicate an ultimate peak demand of 32 MW. These forecasts are based on the assumptions of 1.67 percent annual population growth, no development of Quartz Hill, a 1.5 percent increase in the price of electricity, and an estimated annual load growth of approximately 2.6 percent (R.W. Beck and Associates 1984, pp. III 3-4).

The estimated peak demand of 32 MW corresponds to a population size of 19,600. With the population related to Quartz Hill, this demand would be reached in year 7. The 8 MW of additional dependable capacity would have a cushion effect to consider adding generating capacity beyond year 7.

Transportation - The major thoroughfare connecting the north and south of Ketchikan is Tongass Avenue. Traffic counts taken by Alaska Department of Transportation and Public Facilities (DOT/PF) in May 1982 indicated an average weekday traffic count of 21,929 trips (northbound and southbound) through the tunnel on Tongass Avenue (KGB 1983a, p. 74). Traffic at the tunnel was in excess of the hourly capacity between 11 am and 6 pm on weekdays (KGB 1983c, p. 13).

Two alternative road construction projects have been under consideration to reduce the traffic volume on Tongass Avenue. The proposed Secondary Route would bypass Tongass Avenue to provide north-south access and is estimated to cost $9.6 million (1983 dollars) to construct. The Schoenbar-Quinn Intertie, which is currently under construction, will carry traffic from Bear Valley to the west end of town via a new connecting road. A nonconstruction alternative would be to eliminate parking along Tongass Avenue, making two lanes available for traffic each way. Off-street parking would need to be provided to offset the loss of parking spaces on the street and the opportunities for off-street parking are limited. On other arterial streets leading from new development areas, the streets would need to be widened. Expansion of the privately operated public transit system would help to alleviate the traffic congestion and could supplement any of the alternatives mentioned above.

While traffic congestion currently exists and will continue to worsen under baseline conditions, the cumulative traffic impacts due to the project-related population could be severe in the downtown area. In examining the traffic impacts of the Quartz Hill project, the 1983 per capita vehicle registration factor of 0.9 can be multiplied by the project-induced population of approximately 2,190 in 1990. This calculation yields an addition of about 1,970 vehicles to the number of vehicles under baseline conditions. The total number of vehicles projected for 1990 under the commute option of 16,300 compares to 13,100 vehicles in 1983, representing an increase of about 24 percent.

The state highway running north-south out of Ketchikan is two lanes and is in good condition (Schalep 1987). No traffic counts were readily available; however, the northern portion of the road is the most heavily used because of the 500 people employed by the pulp mill located there. The portion of road from Mile 8 northward is being widened and straightened. The portion of the road south of Mile 8 was described as being fairly curvy but in good condition. The Department of Transportation has all the equipment required to maintain the highway but only three staff members, reduced from nine due to recent staff cutbacks. Thus, road maintenance, such as ditch-clearing, has been delayed for several years. The proposed project would result in a moderate increase in vehicle traffic outside the City of Ketchikan. Assuming the proportion of population in unincorporated areas (0.40) does not change significantly from 1983 and that 20 percent of the above 1,970 vehicles (394 vehicles) would be located in the same area, a 6.1 percent increase would occur in the number of vehicles in unincorporated areas. This may have a moderate impact on vehicle traffic, above baseline conditions. However, it should be noted again that those impacts would be felt by a severely understaffed Department of Transportation (Schalep 1987).

In addition to ground transportation, the project would have an impact on air transportation. Demand for commercial flights would increase as a result of the economic activity associated with the Quartz Hill project. A possible benefit would be expanded service and more competition among the various air carriers.

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The ferry that serves the airport is currently operating at capacity. The borough has requested from the state legislature for FY 85 general funds to cover 100 percent of the $750,000 (1983 dollars) capital cost of an additional ferry. Operating costs would be the responsibility of the borough. The presence of project-related population would probably necessitate that additional ferry capacity be added to the system. The Tongass Narrows Crossing Benefit/Cost Study, completed in 1985, recommended the continuance of the ferry link to the airport through the year 2005, with additional ferry capacity, terminal locations, and expansion occurring as needed. Alternatively, pressure might increase to construct a highway bridge across Tongass Narrows to Gravina Island that would provide road access to the airport. Preliminary studies of several routes for this bridge continue to be conducted.

Ports and Harbors - The City Port and Harbors Department manages a large vessel dock and small moorage for cruise ships, freighters, fishing boats, and pleasure boats. The department operates five harbors, including City Float, Thomas Basin, Hole-in-the-Wall, Knudson Cove, and Bar Harbor. These harbors contain a total of 1,075 slips. The open moorage areas can handle approximately 300 boats belonging to tourists and fishermen (Ensley 1984).

Once the new slips are opened, the harbors will be operated at capacity. Currently there is a shortage of harbor development opportunities. Future expansion could occur at Knudson Cove or through development of a new 350-slip harbor at Saxman, which is currently being evaluated by the Army Corps of Engineers. The lead time required to construct additional slips can be up to 10 years. The standard for estimating future slip needs for the resident population is 1 boat per 12 persons, which reflects current conditions (Ensley 1984).

Without the project, a total of 1,485 slips would be required to meet the moorage needs of the resident population in 1999, representing a shortfall of 105 boat slips assuming development of a 350-slip harbor at Saxman. A total of 1,714 slips would be needed under the commute option, or approximately 230 additional slips by 1999. Based on an average construction cost of $20,070 per slip, the costs associated with providing moorage for the project-induced population in 1999 would be $4.62 million (1983 dollars) (Ensley 1987).

The harbors are owned and built by the Alaska Department of Transportation and Public Facilities and operated by the City of Ketchikan. While DOT/PF provides 100 percent funding for actual harbor improvements, the city is responsible for acquiring and developing upland facilities. Typically, the city has paid these costs through bonding and pays of the principal and interest.

During the operations phase, some people could bring boats to live on. An increase in the number of boats in the open moorage area could cause overcrowding as well as pose health and safety violations, resulting in the need for regulation.

The Quartz Hill project would need an industrial support base with barge and company ferry access provided to the site. Possible seaport sites include the Saxman Seaport, Spruce Mill, Maintenance Facility, South Coast Construction, Wayne Construction, and Seaward Shipyard. Any other area would need to be developed from raw land.

Use of one of the last four facilities would add to the marine travel time but would minimize heavy traffic flows of commuting workers through Ketchikan. Conversely, use of the Saxman Seaport or Spruce Mill would save on marine travel time but workers would need to be transported through town.

Library and Museum - The City of Ketchikan provides cultural services through the library and museum departments. The Tongass Historical Society Museum is operated jointly by the city and Tongass Historical Society, Inc. The city provides the museum with space, staff salaries, telephone, and clerical supplies. The Totem Heritage Center, which is supported by the city, exhibits retrieved totem poles and offers educational programs and workshops emphasizing traditional native art styles. The library is open 7 days a week and provides the services for children and adults.

Both the library and museum are currently operating at capacity in terms of staff. The library facilities are currently overcrowded and expansion is required.

The library has a staff of 9.5 full-time equivalent persons. The demand for library services can be expected to be proportional to the increase in population. There would need to be 1.5-2 persons added to the staff as a result of the project. Based on salary and benefits, the library would need $53,200 of additional funds annually for staff (1983 dollars) (City of Ketchikan 1983).

An additional impact on the library would occur during the construction phase and the early years of the operations phase. Libraries tend to attract unemployed and transient persons as they provide a comfortable place to rest. The magnitude of this impact would depend mostly on the number of job seekers who come to Ketchikan.

The museum staff has six full-time persons to operate both the Tongass Historical Society Museum and the Totem Heritage Center. As with the library, the demand for museum programs is approximately proportional to an increase in population. The project-related impact would be the need to add 1-1.5 persons to the staff. Additional annual funds of about $52,500 would need to be obtained through the city general fund (1983 dollars) (City of Ketchikan 1983).

Recreation - The City of Ketchikan Parks and Recreation Department offers sports activities, recreation classes, workshops, and special events. The Parks Maintenance Division operates nine developed parks and maintains three additional undeveloped sites. The nine parks and playgrounds total 15 ac, with a range in size of 1/8 ac to 4 ac. When the three additional sites are developed, the total of park area will

be about 21 ac. The borough does not have parks and recreation powers. However, there are public parks and facilities within the rural portions of the borough operated by the City of Ketchikan, Alaska Division of Parks, and the Forest Service. These public recreation areas include one 3.5-ac beach, three recreational parks, and Forest Service trails, picnic facilities, and campgrounds.

With the city's park system are two multipurpose fields, one of which accommodates two softball diamonds or one soccer field, and the other accommodates two baseball diamonds or one football field. The city's other facilities include six tennis courts and one outdoor basketball area. The School District has six outdoor basketball areas, which are available to the public during nonschool hours. There are no volleyball courts or track. The absence of a public indoor recreational facility necessitates heavy use of the swimming pools and gymnasiums located at the public schools, churches, National Guard Armory, and the Coast Guard base.

Current indoor and outdoor recreational facilities are in serious short supply and do not meet the needs of the existing population. The shortage of facilities is due, in part, to the reluctance of city residents to support the construction of new facilities that noncity residents would use (Morehouse and Associates 1983, p. 41). Based on national standards that have been adapted to Ketchikan, the majority of the existing athletic and indoor facilities do not meet the demand requirements. Facilities that have exceeded these thresholds are softball, baseball, soccer, track and football fields, outdoor basketball courts, gymnasiums, indoor tennis courts, and handball/racquetball courts. According to the standards, there is no excess capacity for any type of facility (KGB 1983a, p. 109).

The Parks and Recreation Department has 15 full-time equivalent staff to run the department and administer its programs. Assuming that this staff is adequate in size, a standard of 1.03 staff/1,000 population was used in forecasting future staffing requirements. Projections of recreational facilities and staff requirements under baseline conditions are presented in Tables 4-22 and 4-23. Project years 1 and 6 were selected as benchmarks in order to measure the recreational needs over the next 10 years. The estimates of athletic and indoor facility needs indicate that the current need for facilities is greater than the incremental requirements over the next 10 years. A similar situation exists for parks requirements, with the exception of neighborhood parks. The need for neighborhood parks will more than double over the next 10 years.

The 1983 participation rate in classes, leagues, and special events was approximately 2,700 persons at any one time, which represented 19 percent of the total population. This estimate assumes that an individual participates in only one event (Boubel 1983). Participation in programs sponsored by the Parks and Recreation Department would increase by 17 to 20 percent between 1983 and 1994 under baseline conditions. This estimate assumes that the participation rate in these

TABLE 4-22

RECREATIONAL FACILITY REQUIREMENTS BASELINE CONDITIONS
(Number of Facilities)

Facility	Standard (Population)	Existing Facilities 1983	Total Requirements 1983	1989	1994
Athletic Facilities:					
Softball Diamonds*	1/3,000	2	4	5	5
Baseball, T Ball*	1/12,000	1	1	1	1
Baseball, Little League*	1/6,000	1	2	2	2
Baseball, Senior League*	1/12,000	1	1	1	1
Football Field*	1/6,000	1	2	2	2
Soccer Field*	1/6,000	1	2	2	2
Track Field	1/12,000	0	1	1	1
Tennis Courts	1/2,000	6	6	7	8
Outdoor Basketball	1/1,500	7	8	10	11
Indoor Facilities:					
Gymnasiums	1/1,500	5	8	10	11
Tennis Courts	1/6,000	0	2	2	2
Handball/Raquetball	1/3,000	0	4	5	5
Pools	1/6,000	2	2	2	2
Recreation Center	1/12,000	0	1	1	1
Neighborhood Park	1/1,750	4	7	9	9
Regional Park	1/4,500	1	3	3	3
Community Park	1/8,000	1	1	2	2

*NOTE: These facilities are not available at all times for a specific type of activity.

SOURCE: KGB 1983a. Community Goals to 1990: the Comprehensive Plan Update (Draft), p. 109. (Existing Requirements)

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TABLE 4-23

PEAK PARTICIPATION ESTIMATES FOR PARKS PROGRAMS
BASELINE CONDITIONS
(Number of Participants)

Category	1983	1989	1994	Percentage Increase 1983-1994
Class Participants/Week	700	785	837	20
League Players/Quarter	1,000	1,100	1,171	17
Participants in Special Events/Quarter	1,000	1,100	1,171	17
Parks and Recreation Department Full-Time Equivalent (FTE)	15	16	17	13

SOURCE: Boubel 1984.

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programs would remain constant. Staff levels are expected to increase by two full-time persons. This estimate may actually understate the requirements as the staff requirements would depend more on the addition of new parks than on total population.

With the Quartz Hill project, the availability of attractive and well-equipped recreational facilities to residents would be an important factor in maintaining a stable workforce and minimizing social problems. The large block of free time given to most operations workers (seven days off work, every other week) has the potential to be used in nonproductive ways, especially since a strong relationship exists between the amount of free time and alcohol abuse (Laub 1984).

It will be important for the recreational facilities to be brought up to the appropriate levels before inadequacies in facilities and programs and the short supply of parks can be attributed to the population related to Quartz Hill. A comparison of parks and recreation requirements under baseline conditions and with the Quartz Hill project is presented in Table 4-24. As the table indicates, the need for most facilities due to the project-related population would occur after year 1. Some facilities would be strained at that time, including a large multipurpose playing field, gymnasium, and swimming pool. Lead times for development of these facilities is three to five years. The project-induced population is expected to increase after 1994 by approximately 80 persons, which would have a minimal effect on recreational facilities.

An additional neighborhood park would be needed by year 1 and an additional regional park would be needed by year 6. The lead time for developing a neighborhood or regional park is about two years. Three to five years would be needed to develop a large community park (Boubel 1984).

Information on the impact on the programs sponsored by the Parks and Recreation Department is provided in Table 4-25. The impact on programs would represent a 22 to 23 percent increase in demand from baseline conditions in year 1 to Quartz Hill conditions in year 6. This increase in demand compares to 17 to 20 percent during the same period under baseline conditions. While the staff would need to expand, the addition of two persons due to project-induced population may be a low estimate since the new population could demand more diversification of the programs.

The costs of parks and recreational facilities are not available at this conceptual stage. Based on salary and benefit requirements (1983 dollars) (City of Ketchikan 1983), the cost of providing two additional staff persons would be about $70,000. This represents a small proportion of total funds required to meet the recreational demands of the project-induced population. Additional funds would be needed for the capital cost of parks and recreation facilities and supplies and equipment.

TABLE 4-24

COMPARISON OF RECREATIONAL FACILITY REQUIREMENTS
BASELINE AND WITH QUARTZ HILL
(Number of Facilities)

Facility	Standard (Population)	Baseline		Quartz Hill	
		Year 1	Year 6	Year 1	Year 6
Athletic Facilities:					
Softball Diamonds	1/3,000	5	6	6	6
Baseball, T Ball	1/12,000	1	1	1	2
Baseball, Little League	1,/6,000	3	3	3	3
Baseball, Senior League	1/12,000	1	1	1	2
Football Field	1/6,000	3	3	3	3
Soccer Field	1/6,000	3	3	3	3
Track Field	1/12,000	1	1	1	2
Tennis Courts	1/2,000	8	8	9	10
Outdoor Basketball	1/1,500	10	11	12	13
Indoor Facilities:					
Gymnasiums	1/1,500	10	11	12	13
Tennis Courts	1/6,000	3	3	3	3
Handball/Raquetball	1/3,000	5	6	6	6
Pools	1/6,000	3	3	3	3
Recreation Center	1/12,000	1	1	1	2
Neighborhood Park	1/1750	9	10	10	11
Regional Park	1/4,500	3	4	4	4
Community Park1	1/8,000	2	2	2	2

SOURCE: Based on KGB 1983a.

TABLE 4-25
COMPARISON OF PEAK PARTICIPATION ESTIMATES FOR PARKS PROGRAMS
(Number of Participants)

Category	Baseline			Quartz Hill		
	Year 1	Year 6	Percent Increase Year 1 to Year 6	Year 1	Year 6	Percent Increase of Year 1 Baseline
Class Participants/Week	785	837	20	883	962	23
League Players/ Quarter	1,100	1,171	17	1,237	1,346	22
Participants in Special Events/ Quarter	1,100	1,171	17	1,237	1,346	22
Parks and Recreation Department Staff (FTE)	16	17	13	18	19	19

SOURCE: Based on Boubel 1984.

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Funds for the Parks and Recreation Department are obtained primarily from the City of Ketchikan. Approximately 12 percent of calendar year 1983 funds were obtained from the borough. A portion of the local funds is federal/state revenue sharing.

Education - Projections of student enrollment for the Ketchikan Gateway Borough School District without consideration of the Quartz Hill project are presented in Table 4-26. In comparing these baseline growth projections to the school capacity constraints, it can be shown that there is ample capacity within both the junior high and high schools to accommodate baseline growth, at least over the next five years. By year 1, a threshold would be reached in the elementary schools, assuming the North Point Higgins school replaces White Cliff School. The elementary schools would be able to meet the educational needs beyond year 1 only by keeping White Cliff open or by building an additional elementary school.

Funding was secured through a $16.9 million bond to construct a new elementary school at North Point Higgins, which will relieve the existing overcrowding in the elementary schools, and to expand and remodel the Schoenbar Junior High and Ketchikan High schools. The new elementary school is expected to be completed by summer of 1986 with space for 350 students. The school is designed to expand to 550 students if the need exists. Ketchikan High School accommodates an additional 100 students as of summer 1985. The old White Cliff Elementary School can continue to be used only if it is rehabilitated to eliminate the structural and fire code violations. The school district is investigating options for use of the White Cliff School, (Van Wechel 1984).

In addition, $2 million was appropriated from the state legislature and Ketchikan Gateway Borough to construct a new Revilla Alternative High School. The Revilla Alternative High School was completed in the summer of 1984 and accommodates 75 students. Schoenbar Junior High School, which was expanded for an additional 100 students, was completed in the fall of 1985.

The estimated number of school children expected from the Quartz Hill-related population and teacher requirements are presented in Table 4-27. It was assumed that the school children would be distributed evenly across all grades. In comparing these estimates with the capacity levels presented in Table 4-26, it can be seen that the elementary schools would not be able to accommodate the addition of approximately 350 students without either keeping White Cliff open or building another elementary school. As the White Cliff school is currently in poor condition, this may not be a viable option, particularly for long-range planning. The estimate of 350 elementary students does not include baseline growth or growth due to other developments.

TABLE 4-26

ENROLLMENT PROJECTIONS WITHOUT QUARTZ HILL PROJECT

School Name	83-84	Year -4	Year -3	Year -2	Year -1	Year 1	Current Capacity 1984	Planned Capacity Year -4	Planned Capacity Year 1
Elementary	1,298	1,314	1,331	1,348	1,365	1,383	1,275	1,625	1,775 1/ 1,375 2/
Shoenbar Junior High School	360	365	370	375	379	384	400	500	500
Ketchikan High School	705	715	723	732	741	750	900	900	900
Revilla Alternative High School	40	40	41	42	43	44	45	45	45
TOTAL	2,403	2,434	2,465	2,497	2,528	2,561	2,820	3,270	3,420 1/ 3,020 2/

1/ With White Cliff.
2/ Without White Cliff.

SOURCE: Van Wechel 1984.

TABLE 4-27

ESTIMATED NUMBER OF SCHOOL CHILDREN
RELATED TO QUARTZ HILL POPULATION 1/

Project Year	Elementary	Junior High	High	Total	Number of Teachers 2/
-3	22	6	13	41	3
-2	143	40	82	265	19
-1	146	41	84	271	19
1	265	74	152	491	35
2	303	84	174	561	40
3	303	84	174	561	40
4	346	96	198	640	45
5	364	101	209	674	47
6	376	104	216	696	49
7	380	105	218	703	50
13	381	106	219	706	50

1/ Kindergartners are counted as 0.5 school child because of their half-time student status.

2/ Based on pupil-teacher ratio of 14.2 (Van Wechel 1984).

By 1989, Schoenbar Junior High is expected to have an excess capacity of approximately 100 students. This school would be able to accommodate growth from Quartz Hill, but it would cause the school enrollment to reach its capacity. With the addition of junior high school students attributed to baseline growth after 1989, this school could exceed its capacity. As further expansion of the junior high school is not an option, an additional secondary school may need to be constructed. The high school, with its capacity of 1,100 students, would be able to accommodate the growth associated with Quartz Hill as well as baseline growth.

For new capital improvements, a general obligation bond would be floated for the entire cost of the project. Up to 50 percent of the capital cost would be reimbursable by the state. The remaining cost would be paid by the local government, with the property tax as the principal source of local revenues.

The cost of constructing a new 350-student elementary school would be approximately $10 million (1983 dollars) (KGB School District 1983, p. 28). The lead time required for constructing a school of this size would be from one to two years.

The funding sources for the school district's operating budget are state (75 percent), local (24 percent), and federal (1 percent). The per capita state funding is based on the fall ADM head count and, therefore, does not cover students who begin attending school from mid-October through June. The annual operating budget for a 350 student elementary school would be approximately $1 million (1983 dollars).

Social Services - The social service delivery system in Ketchikan provides services to all age groups. Information on social service agencies was obtained through a questionnaire administered by Morehouse and Associates and filled out by 15 agencies in August 1983 and through informal interviews conducted with 5 agencies in February 1984. The current situation is that caseloads are increasing at a time when funding is diminishing due to federal and state cutbacks. This requires that staff carry a larger number of caseloads than normally required, necessitating an emphasis on case management rather than primary treatment. The major constraints to meeting all of the social service demands are inadequate resources (staff and facilities) and an unreliable source of funding.

The current capacity of agencies to physically accommodate the demand for services varies from agency to agency. The Gateway Community Mental Health Center, which includes the Alcoholism Program, needs additional capacity in its residential alcohol and drug rehabilitation program and a holding facility for inebriates. A new residential treatment facility was completed in 1985. Additional facility needs include a facility for drug-dependent adults and juveniles, a medical detoxification center, and a halfway house.

Ketchikan already has a high alcoholism problem. Alcohol often plays a major role in violent events, such as motor vehicle accidents, misdemeanors, crime, suicide, and domestic violence. Alcohol abuse, therefore, affects other agencies, such as Women In Safe Houses (WISH), Juvenile Probation, Division of Social Services, and the emergency medical system administered by the Ketchikan Fire Department and Pond Reef Fire Department. Because of the current overload on the social service agencies, it is important that the existing services are increased to an appropriate level before construction begins on Quartz Hill.

There are no service agencies located in Saxman to meet the specific needs of Native Americans. Since Saxman is an historically disadvantaged and culturally isolated community, the need for social services could increase if Saxman were to be relatively worse off with Quartz Hill. The disparity between Saxman and the non-Native community would increase if Saxman residents did not benefit from employment opportunities but experienced some of the adverse impacts such as an increased cost of living.

In case studies conducted of energy-impacted communities of the Rocky Mountain states, it has been found that the percent increase in the number of caseloads has been greater than the percent increase in population. In a study conducted on Craig, Colorado, it was found that newcomers had a disproportionately high share of alcohol-related problems, although longtime residents were not exempt (Lantz et al. undated). Data available on the incidence of mental health caseloads in Campbell County, Wyoming, an area that experienced a much more rapid growth in population than would Ketchikan (16,000 to 26,000 in 3 years) due to mining, indicate that the number of caseloads increased by 2.2-2.6 times the percentage increase of new residents (Weisz 1979). In applying a factor of 2.4 in Ketchikan, it can be expected that between year -6 and year 2, when population would increase by 24 percent, the number of caseloads could increase by 58 percent. The number of caseloads could increase by 64 percent, taking into account the presence of speculative in-migrants. This effect could be expected for the Gateway Community Mental Health Center, Division of Social Services, WISH, and Juvenile Probation, as well as on the public schools in dealing with child behavior problems.

Information on the services provided and the expected impacts with the Quartz Hill project is presented in Table 4-28 for each potentially impacted social service agency. Factors that would contribute to the increase in demands for social services with Quartz Hill are the following:

- Large blocks of free time for operations workers.
- Presence of speculative in-migrants and other transients who are unable to obtain work.
- A total of 52 liquor outlets open as long as 21 hours a day.

TABLE 4-28
IMPACTED SOCIAL SERVICE AGENCIES

Agency	Services Provided	Current Conditions	Future Demands With Quartz Hill	Funding Sources
Ketchikan Association of Parents for People with Special Needs (KAPPS)	Advocacy and home support services to make life as normal as possible for individuals with special needs and their families.	1 part-time director to meet the needs of 14 families.	The influx of families would increase proportionately the number of persons needing services.	Alaska Office of Developmental Disabilities
Women in Safe Homes (WISH)	24-hour crisis line and shelter for victims of domestic violence and sexual assault, preventative educational program, counseling for women and batterers.	12 staff FTE working at full capacity. 318 clients July-December 1983.	Transients and speculative in-migrants often have minimal coping skills, little money, and no jobs, resulting in potential for domestic violence. Expect increased need for staff, but facility is sufficient. Direct service staff would probably need to to be increased on every shift, excluding night shift, resulting in need for 3 additional counselors.	Alaska Department of Public Safety; Local revenue sharing funds
Southeast Alaskan Health Systems Agency	Development of long and short range health plans for region and communities, technical assistance to organizations on grant writing, resource development, program development and evaluation, and review of health care proposals.	2-1/2 staff FTE Funds and staffing have been sharply reduced, while demand for services has increased.	The increased population in Ketchikan would put a strain on existing human service programs, resulting in need for additional funds.	Federal
Gateway Opportunity Center	Group home, respite care, vocational evaluation, and sheltered employment for developmentally disabled adults.	7 FTE staff. Shortage of staff and equipment.	The influx of families would increase proportionately the number of persons needing services.	Alaska Office of Developmentally Disabled

TABLE 4-28 (Continued)

IMPACTED SOCIAL SERVICE AGENCIES

Agency	Services Provided	Current Conditions	Future Demands With Quartz Hill	Funding Sources
Ketchikan Children's Home	Two residential treatment centers for adolescent males and females.	4-1/2 FTE staff. Additional need for treatment staff, recreation director, and treatment coordinator.	The influx of families would increase proportionately the number of persons needing services.	State
Cooperative Extension Service and 4-H	Educational programs in the areas of agriculture, natural resources, home and family community development, marine advisory, and youth development.	2-1/2 FTE staff. Services are limited to staff availability.	The influx of families would increase proportionately the number of persons needing services.	U.S. Dept. of Agriculture
Ketchikan Health Center	Preventive health screening, generalized public health nursing, and home skilled nursing home health care.	12 FTE staff. Staff insufficient to meet demand.	Increase need for services directed at families, such as immunizations, parenting, communicable disease control, and family planning.	State, General Fund
Juvenile Probation	Process juvenile delinquent referrals, perform intake process on juvenile complaints, investigate complaints, make determination to dismiss, divert, or request from informal or formal probation supervision.	3 FTE staff. Staff adequate to handle caseloads. Need for a substance abuse residential treatment program for juveniles.	The influx of families would increase proportionately the number of persons needing services. The lack of recreational outlet for minors and substance abuse treatment facilities will have a compounding effect on demand for services.	State
Division of Social Services	Child and adult protection services, licensing of day care homes and centers, foster homes, child and adult residential facilities, adult foster homes, adoptions.	10 FTE staff for 560 cases per year. Staff unable to handle preventive work with marginal families.	Stresses associated with geographic isolation, unfulfilled expectations about obtaining jobs would make incoming population high risk for social services needs.	State

TABLE 4-28 (Continued)

IMPACTED SOCIAL SERVICE AGENCIES

Agency	Services Provided	Current Conditions	Future Demands With Quartz Hill	Funding Sources
Division of Public Assistance	Financial, food, and medical services provided to needy children and adults who meet the eligibility requirements of the various programs.	10 FTE staff. Staff overworked to handle caseloads.	Unsuccessful job seekers would place stress on the Food Stamp Program and state-funded General Relief Medical Programs. Demand increases with increase in transient population.	Federal, State
Alaska Native Health Center	Ambulatory care, in-patient, pharmacy, counseling, prenatal classes, blood pressure clinic, dental care.	22 FTE staff. Able to meet current demand for services.	Little direct impact on services anticipated.	Federal
Gateway Community Mental Health Center	Marriage, family, substance abuse counseling, psychiatric, chronic mentally ill, child abuse, crisis intervention, crisis clinic, support group classes, partial hospitalization, consultation and education services provided for other human service agencies. One to one and group treatment diagnostic for courts, schools, individuals, and other agencies.	11 FTE staff. Staff and facility operating above capacity. Need for a halfway house. Experienced sharp reduction in state funding.	Percentage increase in number of caseloads is approximately 2.5 times percentage increase in population in rapid growth communities.	Alaska Department of Health and Social Services; City of Ketchikan

TABLE 4-28 (Continued)

IMPACTED SOCIAL SERVICE AGENCIES

Agency	Services Provided	Current Conditions	Future Demands With Quartz Hill	Funding Sources
Ketchikan Alcoholism Program (part of Gateway Community Mental Health Center)	Outpatient counseling, alcohol counseling, alcohol residential treatment, day treatment services, relaxation techniques, prehospital screening, hospital aftercare, alcohol residential treatment, alcohol outpatient youth substance abuse program, specialized outreach to homes and employers	11-1/2 FTE staff. Alcohol abuse-related problems are epidemic in proportion to size of Ketchikan and greatly impact all social, safety, and health care services. Staff currently overworked and actual caseloads exceeding capacity for the majority of the programs.	Percentage increase in number of caseloads is approximately 2.4 times percentage increase in population in rapid growth communities. Alcohol abuse will be influenced by geographic isolation, unfulfilled job expectations, large blocks of free time, and ease of alcohol accessibility.	Alaska Office of Alcohol Abuse; Alaska Public Highway Safety Grant; Alaska Department of Corrections; Ketchikan General Fund; State Revenue Sharing

- Presence of up to 200 construction workers in Ketchikan every weekday with no planned activities.

- Lack of adequate recreational outlets, resulting in boredom.

- Adaptive demands on newcomers by the environment (e.g., rain, geographical isolation).

- Stress on long-time residents.

- Rapid influx of new residents with different value systems.

- Persons on fixed incomes who would become relatively worse off.

The increased caseload would place many stresses on the mental health delivery organization. Such problems could include meeting the special needs of the newcomers, staff burnout, staff turnover, and uncertainty of funding.

Law Enforcement - Law enforcement in the city is provided by the Ketchikan Police Department. The police department is housed in rental space until completion of a new facility, which is expected to increase the capabilities and efficiency of the department (Anslinger 1984). The Ketchikan Police Department has a staff of 33 officers, making the ratio of officers to the population of the City of Ketchikan 2.28 officers/1,000 population.

Law enforcement in the borough is provided by State Troopers. A new regional jail was opened in August 1983 with a capacity of 60 inmates. The capacity of the jail has been exceeded at least once since its opening (Poppen 1984).

The crime rate in Ketchikan is high, which is reflected in the officer-to-population ratio of 2.28, compared to a national standard of 2.0 officers/1,000 population (U.S. Department of Justice 1984). While the distribution of population is about 64 percent city, 36 percent borough, the incidence of reported crime indicates a distribution of about 85 percent in the city and 15 percent in the borough. Criminal activity usually increases in the summer when seasonal population associated with fishing and logging activities increases. There is no reported incidence of prostitution (Morehouse and Associates 1983, p. 44).

With the influx of population related to Quartz Hill, the number of criminal offenses would increase, perhaps disproportionately to the increase in population. An increase in felony crimes, misdemeanors, accidents, and parking and traffic congestion could be anticipated. Case studies in energy-impacted communities in the Rocky Mountain region show that the largest increases in demands for city services occurred in law enforcement and utilities (Weber 1981, p. 4; Murray and Weber 1982, p. 105). In addition, police in almost every energy boom town in the Rocky Mountain region reported a phenomenal growth in criminal activity with the onset of energy development activities (Taft 1981, p. 9).

Using the assumption that the increase in crime would be 2.4 times the increase in population, it can be expected that between 1983 and 1990, when population would increase by 24 percent, the number of criminal offenses would increase by 64 percent. This estimate takes into account the presence of speculative in-migrants. In Evanston, Wyoming, the officer-to-population ratio increased to 3.28 officers/1,000 population during the period of rapid growth. Using this measure, the Ketchikan Police Department would require 7 additional officers in 1990 and two more officers in 1995. An addition of one vehicle would be required, based on a national standard of one vehicle/2,500 population (Leistritz 1981, p. 119). Based on salary and benefit requirements, the cost of increasing the staff due to the Quartz Hill related population would be $346,000 in year 2 (1983 dollars, City of Ketchikan 1983). The City of Ketchikan's General Fund is the source of salary expenses.

Fire Protection - The City of Ketchikan currently has two fire stations (West End and Main Street Stations). The city department has a staff of 19 career and 30 volunteer persons. Saxman is served by its own volunteer fire department. A mutual aid agreement is presently being formalized, which will allow the city and borough departments to come to each other's aid in cases of major emergencies. The Ketchikan Fire Department's strong capabilities, alarm and hydrant systems, and excellent record have helped to establish a relatively low insurance rate in the city. Within the city, the basic response distance is established at 1.5 mi (KGB 1983a, p. 93; Fisher 1984).

Two service district fire departments (Shoreline and South Tongass) and one private fire department (Pond Reef) serve the rural areas. The three noncity fire departments rely completely on volunteers. All of the fire departments, including Ketchikan and Saxman, with the exception of Pond Reef are members of a cooperative fire fighting agreement.

Under baseline conditions, the fire department should be able to meet the needs of the city for the foreseeable future. Beyond the city limits, however, the fire loss and damage of residential property has been over twice that of the city in the last 10 years. The situation is expected to deteriorate as current population and development trends continue. An inadequate water supply to combat fires and the absence of a building code outside the city limits are the major constraints to fire fighting efforts (KGB 1983a, p. 93).

With the commute option, the following four types of impacts can be expected: (1) difficulty in keeping committed volunteer firefighters; (2) increase in number and/or severity of fire calls caused by hastily constructed houses and mobile homes; (3) need for a third fire station to serve the new pockets of population if land development occurs behind Bear Valley; and (4) an increase in the number of incidents proportional to the increase in population.

The employment opportunities that would result from the Quartz Hill project and the urbanization of Ketchikan are two factors that could contribute to the turnover rate of volunteer firemen. The shift from informal to formal mechanisms for providing services may discourage people from spending their time in volunteer services.

The absence of building codes outside the City of Ketchikan would provide an opportunity for land speculators and developers to provide hastily constructed housing, substandard housing, and mobile homes to meet the housing needs of the project-induced population. The lack of an adequate water supply in the borough could make some fires catastrophic. The inability of local government officials to monitor building activity and the lack of a code to enforce standard construction practices may result in a threat to safety for the inhabitants. The inducements to remodel homes to create rental units could result in living spaces that do not provide for safe exit in the event of a fire (Morehouse and Associates 1983, p. 34). The effects of this type of housing development would be an increase in the number and severity of fire calls.

The project-induced population is expected to reside primarily in new subdivisions that may spring up on the periphery of the city limits to take advantage of access to city sewer and water. These pockets of new development would need to meet the standard of the 1.5 mi response distance. This standard would require that a third fire station be constructed and manned if land development occurred behind Bear Valley rather than adding staff and equipment to the existing fire stations. The Fire Chief estimates that the Bear Valley Station would cost $2.2 million in construction and equipment as well as $260,000 in annual operating costs. The $2.2 million estimate is based on the purchase of 2.3 ac of land, construction of a four apparatus fire station with living accommodations for five persons, and the purchase of a fully equipped fire engine. The operating cost was based on one-third of the fire suppression operating budget for 1984.

Medical Services - The project-induced population would place a demand on the medical services of the KGB, including obstetrics, pediatrics, and primary health care. Accidents that could occur at the Quartz Hill site could have an impact on the emergency room coverage.

The city fire department provides emergency medical transportation services within the city limits with marginal service to points 7 and 6 mi north and south, respectively. The Pond Reef fire station and rescue team also provide emergency medical transportation for the borough. This service, which relies on the dedication of volunteers, is currently overtaxed. Saxman's Volunteer Fire Department provides emergency medical services to the community and has increasingly responded to fires and vehicle accidents in the South Tongass area. The city recently formalized a cooperative agreement with the City of Ketchikan and the Ketchikan Gateway Borough for handling emergencies in the South Tongass and Shoreline fire protection service areas. The number of calls could increase disproportionately if the incidents of

alcohol abuse and depression increase. The addition of more people in the borough, particularly in areas outside the city limits, would necessitate development of a more formal institution to meet the emergency medical transportation needs. The Quartz Hill project would hasten that need, although the need would be present even without the project.

In the Ketchikan General Hospital (KGH), the obstetrics area, which can accommodate 8 beds, should not be affected by the project-induced population as there is excess capacity of 6.5 beds per day on the average. Most of the babies born at the hospital are delivered in one of two birthing rooms and the delivery room is rarely used. Presently there are 48 licensed beds for acute care patients and this area could be expanded to accommodate 52 beds. The hospital bed standard used by the KGB is 2.8 to 3.0 beds per 1,000 population (Haase 1984). Based on a total with-project population of 19,570 in year 20, approximately 57 beds would be needed. While this requirement exceeds the existing capacity by 5 beds, a portion of the 44 licensed beds in the nursing home could be used for acute care patients. Therefore, there would be excess capacity of hospital space both with and without the project.

There may be a need to hire an additional registered nurse to cover the emergency room and to communicate with the medical clinic at the Quartz Hill site. The increased demand on services in the emergency room would depend to a large extent on the enforcement of occupational safety standards at the site and the capabilities of the Quartz Hill clinic.

Another source of impacts on the emergency room may be the unemployed job seekers. During the summer, the demand on the emergency room increases because of the summer transient population. Experience from other rapid growth communities has shown that transient people postpone preventative medical care until a crisis situation is reached. Many transient patients are not able to pay for medical services and carry no medical insurance (Morehouse and Associates 1983, p. 54).

The most significant impact of the project-induced population would be the need for an additional primary care clinic having two to three family practitioners. While this need exists presently, the Quartz Hill project would hasten the need. The need for additional medical professionals would be met through the market forces of supply and demand and would not place a burden on publicly provided services.

Social Conditions

<u>Community Attitudes and Quality of Life</u> - The KGB has a small town atmosphere infused with diverse values brought by newcomers. The pioneer spirit of individuality and self-sufficiency are prevalent among both the longtime residents and newcomers. Outdoor recreation, leisurely pace, clean environment, close neighborly ties, and a strong sense of community are highly valued. Ketchikan can be characterized as an informal, friendly, and close-knit community, and residents are

aware of the presence of tourists and other outsiders. Decision-making is carried out in an informal environment, allowing for participatory government.

The population increase associated with the construction phase of the project could cause a disruption in the social environment, especially during the peak construction period. The transient status of the construction work force could cause resentment among the residents, as they could be perceived as a drain on the community's services without contributing any resources to the community in return. The presence of speculative in-migrants would have a similar effect on the social organization. If expectations of economic gain, access to comfortable and affordable housing, and reliable public services are not met, personal frustration could be exhibited through alcohol or drug abuse, domestic violence, and aggressive behavior. Existing residents could also exhibit these types of behavior due to the stress from lifestyle changes. The response by the community to the changes brought about could be to formalize institutions, such as requiring identification to cash checks, structuring interaction with government agencies, and structuring meetings with community leaders (Morehouse and Associates 1983, p. 57). However, the presence of newcomers in the KGB suggests that the social structure has adapted to a changing population, resulting in a moderation of some of these impacts. The present ability of the community to adapt is linked to an historic 1.2 percent annual population increase compared to the expected 3.9 percent annual population increase projected for the first five years.

The assimilation of new operations-related population into the community may be difficult in the first few years, particularly if services have not been brought up to the necessary levels to meet the new demands. The newcomers could have higher expectations of services than the longtime residents, which would increase pressure on the existing services. As the community adjusts to the project-related growth, there should be a higher degree of acceptability of this new population by the current residents. Experience has demonstrated that persons working in hard rock mining tend to be long-term residents and make a commitment to the community.

The influx of operations workers and additional persons filling secondary and locally vacated jobs would change the social organization of Ketchikan. Some of the changes that could be expected are the following: (1) an accelerated pace of urbanization; (2) a more formalized interaction between established groups and newcomers; (3) a formalization of business transactions, social service provisions, and governmental structures; (4) an increased scale and complexity of issues which local governments will have to address; (5) a turnover of merchants and presence of chain stores; and (6) changes in leadership.

The general trend toward a more bureaucratically structured and less friendly community could leave many longtime users of public and private services disinterested in or alienated by the new systems.

The City of Saxman prefers to maintain and enhance its identity and culture as a predominantly Native community. The concerns that Saxman have regarding potential impacts of Quartz Hill on their quality of life include the following: (1) that special classes offered in Native languages not be deleted from the curriculum; (2) that Saxman cannot accommodate any of the incoming population since the high number of existing dislocated residents have a higher priority; and (3) that moderately priced public transportation be extended south to Saxman to mitigate traffic congestion.

Cost of Living - The principal effect of the Quartz Hill project on the cost of living would be the creation of economic disparity between various groups of people. Development of Quartz Hill would result in substantial changes in income in the Ketchikan Gateway Borough due to the relatively high worker wages. The increase in income would enhance the well being and possibly raise the standard of living for those positively affected by the project such as project workers and persons benefiting from the spin-off economic effects. The elderly population, persons on fixed incomes, and persons with limited skills are segments of the population that would experience little change in their incomes but may experience substantial increases in living costs. First-time homebuyers may have financial difficulties in entering the housing market.

An increase in prices could result from the increased demand for many goods and services. Housing costs could be particularly susceptible to the increased demand. The increase in cost of housing could limit the range of housing options for many residents. The elderly, persons on fixed incomes, and persons with limited skills would be those most affected. On the other hand, an improved position of wealth for some of the residents may result from substantial appreciation in the value of existing housing units.

Public Finance

The major consideration for financing major public projects would be the relationship in timing of the expenditure and of the expected revenue. A service standard method was used to estimate the public service and facility costs presented in the previous sections. The results of that analysis indicate that the major public service expenditures that would be required to serve the project-induced population of Quartz Hill would be a new elementary school, playing fields, neighborhood and regional park, additional streets and water and sewer lines, additional city and borough personnel and equipment, and possibly, a new fire station. Some of these public expenditures would be offset by project-related revenues resulting from Quartz Hill employment and personal income. Services and facilities required in the early years of the project would not benefit from project-related revenues due to the normal delay in local governments receiving tax revenues.

Quartz Hill will be located outside existing borough boundaries and will not contribute to the borough tax base. Since U.S. Borax would not be paying local property taxes unless Quartz Hill were annexed by the borough, other methods of raising revenue would need to be evaluated. The sales tax was the largest source of revenue in FY 1983, followed in descending order of importance real and personal property taxes, automobile taxes, and boat taxes (City of Ketchikan Finance Department 1983). An increase in any of these taxes would help finance public services and facilities, but would adversely affect individuals on fixed incomes.

The addition of 1,000 housing units, of which 650 are expected to be single family residences, would have a positive long-term effect on the assessed valuation of the cities of Ketchikan and Saxman and the borough. In looking at the short-term effects, there would be about 700 project-related housing units by year 2. Based on an average market value of $110,000 per unit (1983 dollars)1/ the total project-related housing would have a market value of $77 million. Assuming that 80 percent of the units were located within the city (560) and 20 percent located outside the city (140), the total assessed valuation based on the different mill rates in the city (0.0094) and borough (0.001) would be about $600,000 in 1990 (1983 dollars).

The school district operating expenditures are financed primarily by property taxes and construction of schools is financed by property tax supported bonds. The major area of concern would be the lead time required for construction of a new elementary school by about year 2. Since the lead time could be as long as two years, the need for commitment of funds for capital expenditure would need to be made by year -2.

One shortcoming in increasing property taxes is the time lag between an initial increase in tax base or population and receipt of additional revenues resulting from this change. The timing of the revenue on the sales tax would be beneficial since sales would increase as project-related persons moved into the area. One drawback of increasing sales tax in the city without a corresponding increase in the borough is that, other things being equal, the tax could encourage retail trade to locate outside city limits.

Sales tax and property taxes place the burden of growth on the community as a whole and are generally considered more appropriate to fund programs that benefit the whole community. Equity in paying for the specific services of new residents dictates a heavy reliance on user charges and revenue bond financing to shift the burden of payment from the existing residents.

An increase in user fees could be an attractive source of revenue because the costs of providing services to new developments could be shifted to the new businesses or residents. The City of Ketchikan currently has a user fee ordinance and plans to charge a sewer user fee

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1/ Based on three-bedroom, one-bath home, 1,600 ft^2 in 1983.

as soon as the plant is completed. The city also has hook-up fees, which cover the costs of inspection and engineering. These hook-up fees do not recover the cost of the construction and installation of the main or service lines. In Umatilla, Oregon, an energy-impacted community, growth-induced expansion of services were financed heavily by service charges. The sources of revenues that grew most rapidly during the growth period were sewer connection charges, water meter charges, and building permits. A large percentage of these revenues were transferred to the general fund to pay for increased operating expenditures (Weber 1981, p. 4).

State funds could be available to finance some of public service and facility requirements. As mentioned previously, the need for elementary school would be the largest public expenditure requirement. State reimbursement for schools is set annually.

Other one-time capital expenditures may be made via legislative appropriation and could include outlays for airport runway resurfacing and terminal replacement; construction upgrade or maintenance of state roads; and direct state grants to cover up to 50 percent of eligible costs for municipal public water systems, sewage collection and treatment facilities, and solid waste disposal projects.

The state provides revenue sharing aid to all municipalities, Native village governments outside municipalities, and volunteer fire departments outside cities and boroughs. Unincorporated areas with a certain minimum number of people are entitled to $25,000 per year. Volunteer fire departments outside municipalities receive $10 per resident.

Entitlements for municipalities vary annually depending on general fund availability and are computed according to an established equalization formula that considers the applicant's population, taxable wealth, and tax effort. Additionally, the state may grant funds for certain municipal services such as roads, health facilities, hospitals, etc. The equalization formula is intended to benefit those municipalities with the greatest need for revenue-sharing funds, such as those with a relatively low tax base.

Although population is a factor in the equalization formula, the amount of funds devoted to the program is not population driven but rather determined by executive and legislative decisions. Because of differences in the city and borough millage rate equivalent used in the equalization formula, they receive different per capita allocations. The FY 1983 total allocation for the borough was $604,877. The FY 1983 allocation for the city was $1,468,524, or a $188.85 per capita compared to $48.66 per capita in the borough (Alaska Department of Community and Regional Affairs 1984).

The municipal assistance program shares corporate income tax revenues with incorporated areas of the state. State law (AS 43.20.016) provides for 10 percent of corporate income taxes (petroleum and other) to be allocated to municipalities. The distribution of these revenues

among communities is determined by the relative shares of gross receipts taxes collected in 1978 and current population. Funds in excess of the base amount (approximately $10.6 million) are distributed according to population in incorporated areas. In FY 1982, the share above the base amount was approximately $200 per person; however, per capita shares for municipal assistance in FY 1983 declined to $137 per person and are expected to decline further (Alaska Department of Revenue 1984).

The state capital budget fluctuates widely and for fiscal years 1981 and 1982 approached record levels. The House Research Agency allocated to the Ketchikan Election District $2,819 and $3,574 per capita for FY 1981 and 1982, respectively, for state agency administration and programs related to the district.

4.3.1.3 Temporary Shutdown

Because of increased capital and operating costs, the middle basin of Boca de Quadra alternative imposes a 55 cent per pound cost penalty on the selling price of molybdenum above the Wilson Arm tailings disposal alternative (Randolph 1986). The effect of this penalty is that mine shutdowns could be more likely and last longer with a middle basin Boca de Quadra tailings disposal alternative than with a Wilson Arm tailings disposal alternative.

The following scenario is intended to describe the effects temporary shutdowns would have on employment, personal income, business activity, population, housing, public services, and finances. These effects would be more or less severe depending upon the length and frequency of shutdowns.

In this example, the temporary shutdown is assumed to occur at the end of year 5, 1 year after reaching full production of 80,000 tpd. Within 1 week of announcement of a shutdown, the work force would decrease from 950 to 300 workers. These persons would be needed for clean-up, closing the operations, and implementing long-term maintenance procedures. Within 1 month of the initial cut in work force, the number of workers would decrease to 175. These persons would be responsible for pit dewatering, operation of sedimentation ponds, maintaining access roads, and other maintenance work. The mine is assumed to be shut down for 1.5 years, with production beginning again in year 7. At the restart of production, the mine would begin with a capacity of 40,000 tpd with a workforce of about 625. Within 9 months of the restart, the mine and mill would be expected to increase production to a nominal 80,000 tpd and have a full work force.

The impact analysis is based, in part, on the types of impacts experienced in Leadville, Colorado, where the Climax Mine shut down operations for approximately 2 years. The experience of Climax Mine can be considered somewhat analogous to Quartz Hill as it is located in a rural part of Colorado and the work force lives principally in Leadville. The mine, which has been operating since the 1930s, is the

single major employer in the area. In a three-phase layoff over a 9-month period, work force at the Climax mine decreased from 3,000 to 250. Population of Lake County, in which Leadville is located, decreased by 20 percent (from 10,000 to 8,000) over 15 months (Kochevar 1984).

Employment

The most significant direct impact of a temporary shutdown would be the loss of approximately 1,550 jobs over the 1.5-year period. The loss of jobs would be split about equally between direct and indirect employment as the shutdown would have a ripple effect on the local economy. The number of persons employed either directly at the mine or in secondary jobs who would be affected by mine closure is presented in Table 4-29.

TABLE 4-29

DIRECT AND INDIRECT JOBS
UNDER TEMPORARY SHUTDOWN CONDITIONS
(Number of Jobs, Persons)

Project Year	Direct	Indirect	Total
5-3rd Quarter	951	933	1884
5-4th Quarter	300	294	594
6	175	172	347
7	626	613	1239
8	980	860	1840

The unemployment rate in the Ketchikan Gateway Borough would increase rapidly. At the Climax Mine, the first group of people laid off were the younger, transient miners who quickly left the area. This group comprised about 20 percent of the total work force. The miners laid off in the subsequent period tended to be more established in the community. The majority of these people did not leave the area, but waited for the mine to reopen. In the interim, these miners either collected unemployment benefits and/or worked at temporary jobs. One social phenomenon that occurred was a role reversal whereby it was easier for the wives of miners than the miners themselves to obtain jobs (Kochevar 1984).

Personal Income

The result of the temporary shutdown would be a loss in personal income during the year 5 to year 7 period. The difference in personal income between the proposed project and a temporary shutdown would total $95.0 million. The loss of $95.0 million would include $68.4 million in direct income and $26.6 million in secondary income.

Local and Regional Business Activity

A marked decline in retail sales would occur due to the sharp decrease in personal income. Some new, as well as established, businesses would probably close as a result.

Population

The decision to remain in the Ketchikan Gateway Borough after losing one's job at Quartz Hill or in a secondary job would depend upon length of residence, job opportunities, and perception of the probability and timing of the reopening of the mine. Based on the experience at Climax Mine, it could be assumed that, at a minimum, a large portion of the transient population would most likely leave Ketchikan. The major expense involved in getting to and from Ketchikan would be a factor in deciding whether to relocate. Because of Ketchikan's isolation, fewer people could leave due to a temporary shutdown of Quartz Hill than was experienced at the Climax Mine. Based on a range of 5 to 15 percent of out-migration of the total population, the temporary shutdown could cause a reduction in population of 1,000 to 3,000.

Housing and Land Use

Two types of impacts on housing would occur as a result of the temporary shutdown. The out-migration of 1,000 to 3,000 persons would be equivalent to about 350 to 1,150 households or housing units. The rapid increase in the housing vacancy rate would severely depress the housing market. The second type of impact would be an increase in home foreclosures. The inability of some persons to make their monthly mortgage payments could affect the financial resources of local banks.

Public Services and Facilities

A decline in elementary school enrollment would be the most pronounced impact on public services and facilities. While the population out-migration would cause a decline in school enrollment, the workers who would leave Ketchikan would most likely be younger employees without school-age children. Therefore, the reduction in school enrollment would not necessarily be proportionate to the population out-migration.

According to the Leadville office of the Colorado Department of Social Services, the temporary shutdown at Climax did not result in an increased number of caseloads for mental health, alcoholism, or domestic violence. The department did experience an increased demand for federal assistance programs such as food stamps and Aid to Families with Dependent Children. The largest social problem associated with the job loss mentioned was loss of self-esteem and, for many of the miners, being a recipient of unemployment benefits and other forms of federal aid (Clifton 1984).

In Ketchikan where the number of caseloads in mental health, domestic violence, and alcoholism is relatively high, the number is expected to increase with a temporary shutdown of the mine. Large blocks of free time, geographical isolation, and adverse weather conditions would

exacerbate the need for mental health and substance abuse services. Whether transient workers decided to remain in Ketchikan during the shutdown would be a key factor in determining the magnitude of social impacts that could occur.

Financial Status

The most significant impacts on the financial status of Ketchikan would be the decline in revenues from retail sales.

4.3.1.4 Townsite Option

The townsite option would involve two construction periods and an operations period, which would be the same as for the proposed project's commute option. The townsite would be constructed concurrent with the mine. The work force and schedule for the construction phases would be the same as for the commute option.

The preoperation phase would last two years, from year -2 through year -1. It is assumed that the families of married personnel would move into Ketchikan during this period. The operation phase would commence in 1989. The work schedule would be a 5-day, 40-hour work week for all workers. The operations personnel would reside at a townsite near the Quartz Hill project site beginning with project startup.

Employment

Direct employment would consist of persons working on construction and operations at the mine site, construction at the townsite, and at the U.S. Borax office in Ketchikan. The work force requirements for mine construction, operations, and the Ketchikan office would be the same number as for the commute option. The work force requirements for the townsite construction would average 200 and peak at 250.

Indirect employment would involve persons working in the construction, trades, services, and government jobs that would be created as a result of the Quartz Hill project. The ratio of direct to indirect jobs created would be the same as for the commute option.

During peak construction, the Quartz Hill project would directly employ about 1,530 persons. At that time there would also be about 600 persons indirectly employed. By year 12, direct permanent employment would be approximately 1,000 persons and indirect employment would increase to about the same level. Approximately 60 percent of these indirect jobs would be at the townsite. Similar to the commute option, the Quartz Hill project would result in long-term employment of approximately 2,000 persons.

The distribution of employment benefits among the local and nonlocal populations is presented in Table 4-30. Because of the limited local labor pool, the project would attract a large number of outsiders, including other Alaskans and residents of other states. The local share of employment would increase over time. Employment by local residents would represent 17 percent of total employment during peak construction and 43 percent of total employment by year 12.

TABLE 4-30

DIRECT AND INDIRECT JOBS CREATED
BY QUARTZ HILL PROJECT
TOWNSITE OPTION

Project Year	Local			Nonlocal			Grand Total
	Direct	Indirect	Local Total	Direct	Indirect	Nonlocal Total	
-4	8	8	16	72	19	91	107
-3	50	51	101	432	120	552	653
-2	173	178	251	1,360	416	1,776	2,027
-1	147	145	292	504	340	844	1,136
1	213	209	422	498	488	986	1,408
2	237	232	469	554	543	1,097	1,566
3	239	234	473	572	548	1,120	1,593
4	289	284	573	782	664	1,446	2,019
5	294	288	582	686	672	1,358	1,940
6	294	288	582	686	672	1,358	1,940
7	297	291	588	694	681	1,375	1,963
8	294	288	582	686	672	1,358	1,940
9	294	288	582	686	672	1,358	1,940
10	297	291	588	694	681	1,375	1,963
11	297	291	588	694	681	1,375	1,963
12	297	291	588	694	681	1,375	1,963

In comparing the with-project employment forecasts to baseline employment forecasts, the results indicate that the project would accelerate the growth in jobs by 13 years. The number of jobs in year 2000 under baseline conditions would be approached in 1987 under the townsite option.

Personal Income

The impacts on personal income for the townsite option would be similar to those for the commute option.

Local and Regional Business Activity

The population increase in the Ketchikan Gateway Borough and at Quartz Hill would generate an increase in volume of new business for area firms. Local businesses would expand their inventories to supply goods and services directly to Quartz Hill and/or to serve the needs of additional residents. The types of impacts that could occur under the townsite option would be similar to the impacts expected under the commute option. The positive impacts on local businesses could be diluted by the business activity that would occur either at Quartz Hill or bypass Ketchikan. The extent to which this would occur cannot be quantified.

Population

Average annual population growth in the Ketchikan Gateway Borough due to the Quartz Hill project with the townsite option would be 2.4 percent during the year -4 to year 2 period, 1.2 percent during the year 2 to year 7 period, and 1.0 percent during the year 7 to year 17 period. This compares to average annual growth rates of 1.2 percent, 1.2 percent, and 1.1 percent under baseline conditions for those three periods, respectively. These with-project growth rates, as compared to baseline growth rates, are presented in Table 4-31.

A rapid period of population growth would occur from 1986 through 1988 when the preoperations personnel would be living in Ketchikan. Local jobs vacated by Ketchikan residents for construction jobs at Quartz Hill would be another factor contributing to the population influx. The project-induced population would reach a peak of about 1,300 persons by the end of year -1. The number of newcomers would decrease to about 800 by year 2. The decrease in population can be attributed primarily to the preoperations personnel who would subsequently move to the townsite. The project-induced population would stabilize at approximately 800 persons for the life of the mine.

The population of the townsite would start out with about 1,110 persons in year 1. Between year 1 and year 5, the population would increase to approximately 1,900. The ultimate population expected at the townsite, including operations and secondary workers and their families, would be about 2,000.

TABLE 4-31

POPULATION IMPACTS IN
KETCHIKAN GATEWAY BOROUGH
TOWNSITE OPTION

Project Year	Baseline	Baseline and Quartz Hill (excluding speculative in-migrants)	Baseline and Quartz Hill (including speculative in-migrants)
-4	14,920	14,968	14,993
2	15,900	16,721	17,059
7	16,944	17,717	18,141
12	18,057	18,829	19,253
17	18,759	19,557	19,989

In comparing the with- and without-Quartz Hill population projections for the Ketchikan Gateway Borough, the estimates indicate that the project would accelerate population growth by about 4 years. The baseline population of 18,759 in year 15 is comparable to the with-project population in year 11. Total population in the Ketchikan Gateway Borough in year 15, including the effects of Quartz Hill, would be 19,544. If the effects of the presence of speculative in-migrants are taken into account, the project would accelerate growth by an additional year.

The regional population impacts would be similar to those for the commute option.

Housing and Land Use

The result of the population influx into the Ketchikan Gateway Borough would be a requirement of nearly 300 permanent and 150 temporary housing units (mobile homes) by year -1. The temporary housing units would be needed to accommodate the preoperations personnel and their families. After year -1, no additional housing units would be required. The housing requirements by type of unit are presented in Table 4-32. These units would be required by the Ketchikan office personnel and the secondary population.

Most of the housing impacts would occur during the year -4 to year -1 period, stemming from the need to provide a large number of units in a short time. The short-term housing needs of the preoperations workers could be met through the provision of mobile homes. The fluctuations in demand for housing between year -1 and year 20 could cause vacancies with respect to mobile homes. The vacancies could occur among other housing types and this type of impact would be difficult to control.

The types of impacts on housing supply and prices in the KGB mentioned under the commute option would be expected to occur under the townsite option. The impacts would be short term and no impacts due to Quartz Hill would occur beyond year -1 if the mobile homes were either dismantled or occupied by new residents.

Public Services and Facilities

At the townsite, all of the services and facilities, with the exception of schools, law enforcement, and postal services, would be provided by U.S. Borax. These services would be provided initially by U.S. Borax and later be the responsibility of the town residents. Those services and facilities provided by U.S. Borax would include housing, streets, sewage treatment, water supply, electricity, telephone, and mail.

Within the KGB, some services and facilities are at or beyond capacity at the present time taking into account planned expansions. These were discussed in detail under the commute option and include recreation, schools, social services, ports and harbors, landfill for solid waste disposal, library, museum, and transportation. Other services and facilities meet current demand, but would need to be expanded regardless of Quartz Hill. The additional population growth attributable to Quartz Hill, however, would alter the timing and

TABLE 4-32

HOUSING REQUIREMENTS IN KETCHIKAN DUE TO QUARTZ HILL PROJECT
BY TYPE OF UNIT
(Number of Units)

TOWNSITE OPTION

Project Year	Single Family	Multi-Family	Mobile Home	Total	Net Change From Previous Year
-3	50	50	10	110	+110
-2	200	50	150	400	+290
-1	200	50	200	450	+50
1	200	50	25	275	-175
2	200	50	40	290	+15
7	200	50	25	275	-15
12	200	50	25	275	0
20	200	50	40	290	+15

magnitude of these expansions from baseline conditions. Services and facilities that come under this category are fire prevention, law enforcement, sanitation collection, wastewater collection system, and streets. Services and facilities that have excess capacity and would be able to accommodate 20 years of future growth related to the townsite option are water supply, wastewater disposal, telephone system, electrical energy, and medical. The impacts of the Ketchikan population related to the townsite option are discussed for only those services and facilities that fall within the first and second categories, with the exception of staffing requirements for solid waste collection.

Solid Waste - The project-induced population would not have any impact on the planned incineration capabilities of Ketchikan. The incinerator, which is designed to meet the needs of a population of 19,800, would be sufficient under the townsite option until after year 20.

Based on a long-range estimate of an additional 190 new accounts for solid waste collection, beginning in year 2, the Department of Public Works would need an additional staff person to work 10-15 hours per week. The cost of hiring an additional sanitation worker one-third time would be about $12,200 per year (1983 dollars) (City of Ketchikan 1983).

Street Maintenance - The project-induced population of about 800 would require one to two additional staff to maintain streets. Two alternative methods have been used to calculate impacts; these methods are the same as described in the commute option.

Transportation - While traffic congestion along Tongass Avenue currently exists and would continue to worsen under baseline conditions, the problem would be exacerbated due to the cumulative impacts of the Quartz Hill-related population. In evaluating the impacts, the number of vehicles that would be present in Ketchikan in 1988 was considered, as that year represents a period of peak population. The construction and preoperations workers were not included in the total population as they would be in Ketchikan on weekends only when the traffic problem is not as great. Using the 1983 per capita vehicle registration factor of 0.9, the project-induced population would own 630 vehicles. The addition of these vehicles would represent a 14 percent increase in vehicles from present conditions.

A very small increase in vehicle traffic would occur outside the City of Ketchikan because of Quartz Hill. Assuming the proportion of population in unincorporated areas (0.40) does not change significantly from 1983 and that 20 percent of the above 630 vehicles (126 vehicles) would be located in the same area, a 2.2 percent project-induced increase would occur in the number of vehicles in unincorporated areas. This would be a negligible increase and impact above baseline conditions, although the Department of Transportation is presently severely understaffed (Schalep 1987).

The ferry that serves the airport is currently operating at capacity. The addition of 800 persons related to the Quartz Hill project could necessitate an additional ferry or a larger ferry to replace the existing one.

Demand for commercial flights would increase as a result of the economic activity associated with the Quartz Hill project. A possible benefit would be expanded service and more competition among the various air carriers.

Ports and Harbors - A total of 1,485 boat slips would be required to meet the demand for moorage from the baseline population in year 11. A total of 1,550 slips would be needed under the townsite option. Based on a project-induced demand of 65 slips and an average cost of $20,070 per slip, the costs associated with providing moorage for the additional population in year 11 would be $1.30 million (1983 dollars).

During the preoperations phase, some people could bring boats to live on. An increase in the number of boats in the open moorage area could cause overcrowding as well as pose health and safety violations.

Library and Museum - The demand for library services can be expected to be proportional to the increase in population. In applying the existing standard of 1 staff/1,500 population, the project-induced population of 800 would necessitate a part-time librarian. Based on salary and benefit requirements, the library would need $13,300 of additional funds for staff (1983 dollars) (City of Ketchikan 1983).

Similar to the library, the demand for museum programs is considered to grow in proportion to an increase in population. Based on the existing planning standard of 1 staff/2,080 population and a project-induced population of 800, a part-time person would be needed. Based on salary and benefit requirements, additional funds of about $17,500 would need to be obtained through the city general fund (1983 dollars) (City of Ketchikan 1983).

Recreation - Projections of recreational facilities and staff requirements under baseline and with-Quartz Hill conditions are presented in Table 4-33. Project years 1 and 6 were selected as benchmarks in order to measure the recreational needs over the next 10 years. The estimates of athletic and indoor facility needs indicate that the current inadequacy of facilities is greater than the incremental requirements caused by the Quartz Hill project over the next 10 years. The recreational requirements of the project-induced population would be playing fields, tennis court, and a neighborhood park. Based on the planning standard of 1.03 staff/1,000 population, 1 staff person would be needed to meet the project-related requirements. The cost of staff to the city would be $34,300 (1983 dollars) (City of Ketchikan 1983).

Education - The Quartz Hill project would have impacts on both the Southeast Islands School District (SEISD) and the Ketchikan Gateway Borough School District.

TABLE 4-33

COMPARISON OF RECREATIONAL FACILITY REQUIREMENTS
BASELINE AND WITH QUARTZ HILL
TOWNSITE OPTION
(Number of Facilities)

Facility	Standard (Population)	Baseline		Quartz Hill	
		Year 1	Year 6	Year 1	Year 6
Athletic Facilities:					
Softball Diamonds	1/3,000	5	6	5	6
Baseball, T Ball	1/12,000	1	1	1	1
Baseball, Little League	1/6,000	3	3	3	3
Baseball, Senior League	1/12,000	1	1	1	1
Football Field	1/6,000	3	3	3	3
Soccer Field	1/6,000	3	3	3	3
Track Field	1/12,000	1	1	1	1
Tennis Courts	1/12,000	8	8	8	9
Outdoor Basketball	1/1,500	10	11	11	12
Indoor Facilities:					
Gymnasiums	1/1,500	10	11	11	12
Tennis Courts	1/6,000	3	3	3	3
Handball/Raquetball	1/3,000	5	6	5	6
Pools	1/6,000	3	3	3	2
Recreation Center	1/12,000	1	1	1	1
Neighborhood Park	1/1,750	9	10	9	10
Regional Park	1/4,500	3	4	4	4
Community Park	1/8,000	2	2	2	2

The SEISD has jurisdiction for education outside of the borough and is required to provide educational services for 8 or more students in grades 1-8 and for 1 student in grades 9-12 . A school at the townsite would, therefore, come under their jurisdiction. If construction families moved to Quartz Hill, temporary modular classrooms could be set up in a relatively short time. Modular classrooms could also be used at the townsite if only a small school were constructed. For a small school of 8 to 40 students, the SEISD would need a lead time of 2 to 3 months to provide the staff and equipment if a building were available. The SEISD does not have bonding power, whereas the Ketchikan Gateway Borough School District has bonding power. The vast proportion of funds for a SEISD school would come from the state (86 percent) and the remainder of funds (14 percent) would come from a federal grant. For the construction of a large school (greater than 40 students), the lead time required to obtain the funds would fall within the 1.5 to 2.5 year range. Under the most optimistic scenario, the SEISD would make a budget request in November in order to receive the appropriated funds in July. School construction would occur the following spring. The SEISD anticipates that there would be no problem in obtaining the funding (Weinstein 1984).

The pupil-teacher ratio would be about 13:1. SEISD can get teachers on board in 1 to 2 months and typically the number of applications greatly exceeds the number of available positions. Some teachers would be available locally. The school at the townsite would create the need for additional administrators at Quartz Hill but not in Ketchikan (Weinstein 1984).

The operating costs for the whole district were $9,665 per student in 1983 (Weinstein 1984). The costs of transporting specialists to and from Quartz Hill would come out of this operating budget.

The most significant impact of the Quartz Hill project on the SEISD would be the uncertainty of which option U.S. Borax would select and, if a townsite were selected, the timing of the townsite.

The Ketchikan Gateway Borough School District would be impacted from the project-induced population of 800. The estimated school enrollment and teacher requirements are presented in Table 4-34. It was assumed that the school children would be distributed evenly across all grades. These estimates indicate that fluctuations in school enrollment would occur with peak enrollments experienced in years -3 to -1 and again in years 3 and 4. These interim requirements could be met most effectively through temporary modular classrooms rather than through the construction of permanent classrooms. The long-term increase of 110 elementary students attributed to Quartz Hill would exceed the elementary school capacity unless White Cliff School were to remain open. While a new elementary would be needed after year 1 under baseline conditions, the Quartz Hill related population would comprise 1/3 of the capacity of the school. The Schoenbar Junior High and Ketchikan High schools would have the capacity sufficient to accommodate the 30 junior high and 60 high school students.

TABLE 4-34

ESTIMATED NUMBER OF SCHOOL CHILDREN
RELATED TO QUARTZ HILL POPULATION

TOWNSITE OPTION

Project Year	Elementary	Junior High	High	Total	Number of Teachers 1/
-3	22	6	13	41	3
-2	161	45	92	298	21
-1	153	43	88	284	20
1	106	30	61	197	14
2	114	32	65	211	15
3	103	29	59	191	13
4	127	35	73	235	17
5	110	31	63	204	14
7	107	30	61	198	14
13	107	30	61	198	14

1/ Based on pupil-teacher ratio of 14.2 (Van Wechel 1984).

The construction cost of a new 350-student elementary school would be approximately $10 million (1983 dollars) (Ketchikan Gateway Borough School District 1983, p. 28). The cost attributed to Quartz Hill school enrollment impacts would be $3.3 million. The lead time required for constructing a school of this size would be from 1 to 2 years.

Social Services - The impacts of the project-induced population on social service agencies are difficult to predict. With the townsite option the only period of rapid growth in Ketchikan would be from year -2 to year -4. During this time the number of caseloads could increase disproportionately to the increase in population. The types of impacts that could occur during this period are discussed under the Proposed Project. After 1988 the number of caseloads would probably increase proportionate to population growth. At the townsite, a permanent or itinerant mental health and substance abuse worker would be required to serve the needs of that population because the townsite would fall within the program's catchment area.

Law Enforcement - Based on a planning standard of 3.28 officers/1,000 population, the long-term needs for the Ketchikan Police Department would be to hire 2.5 officers by year 7 at an annual cost to the city of $124,000 (1983 dollars) (City of Ketchikan 1983). During the rapid growth period of year -3 to year -1, the short-term needs would be to hire 3-4 additional police officers.

Fire Protection - The project-induced population is expected to reside primarily in new subdivisions that may spring up on the periphery of the city limits to take advantage of access to city sewer and water. The population associated with the growth during 1986-88 is expected to live in mobile home parks. These pockets of new development would need to meet the fire standard of 1.5 mi response distance. This standard would require that a third fire station be constructed if land development occurred behind Bear Valley. Otherwise, staff and equipment would need to be added to the existing fire stations. A cost estimate for a fully equipped fire station is not available.

Social Conditions

Quality of Life - Four possible locations for townsites are being considered, including Keta, Bakewell, Wilson I, and Wilson IIa. These sites have been evaluated for site topography, microclimate, site configuration, recreation potential, site development characteristics, exposure to sunshine, exposure to natural hazards, quality of view, accessibility to Ketchikan, accessibility to the work place, and environmental impact.

Keta Townsite - The Keta townsite would be developed if a project development concept was selected that would place a road in the Keta River drainage and the Blossom access road were closed. The townsite would occupy 120 ac, necessitating a predominance of multifamily housing to accommodate the approximate 2,000 residents. Positive factors include moderately good recreation potential and fairly good

views for most residents. The negative aspects of the Keta townsite, which outweigh the positive factors, would be its confinement between steep slopes, resulting in a windy site, minimal exposure to sunlight, talus deposits that could be a problem for adequate foundations, and the environmental impacts on the estuary. The avalanche hazards would restrict the movement of residents from November through May and make traveling to the work place unsafe at times (Simons 1980).

Bakewell Townsite - The permanent town situated between Bakewell Lake and Bakewell Arm would occupy 250 ac. The positive attributes include a large open site with good elevation, exposure, and view. The configuration of the site would be amenable to compact development with centrally located facilities. The recreation potential would be quite good due to its access to Bakewell Lake. The drawbacks of the Bakewell townsite would be the northern orientation of the site, resulting in minimal exposure of sunlight during the winter and poor accessibility to the work place. Workers would need to be transported to work either by ferry and by a road connecting the townsite to the Wilson wharf (Simons 1980).

Wilson I Townsite - This townsite is located on two plateaus that would need to be joined by a 4,000-ft-long winding road. This site, which would occupy 120 ac, is not compact because of the vertical separation between the two development areas. The site would afford good access to the work place, but a bridge would be needed. Views to the north, east, and west would be possible, but the view south across Wilson Arm would be blocked. The northern orientation of the site would result in minimal exposure to sunlight during the winter. Odor from decaying fish could be a problem during the spawning season (Simons 1980).

Wilson IIa Townsite - This townsite would occupy approximately 200 ac. Similar to the Wilson I townsite, a bridge would be needed to transport workers to the work place. This site would be located near riparian habitat, but could be located on the westernmost part of the valley above the floodplain. Exposure to sunlight during the winter would be quite good, but the view would not be exceptional.

Public Finance

The major consideration for financing major public projects would be the relationship in timing of the expenditure and the expected revenue. The major public service expenditures that would be required to serve the project-induced population of Quartz Hill would be part of a new elementary school, playing fields, neighborhood park, additional streets and water and sewer lines, additional city and borough personnel and equipment, and possibly, a new fire station. Some of these public expenditures would be offset by project-related revenues resulting from Quartz Hill employment and personal income.

Since U.S. Borax would not be paying local property taxes unless Quartz Hill were annexed by the borough, other methods of raising revenue would need to be evaluated. An increase in sales taxes, real and property taxes, automobile taxes, and/or boat taxes would help finance public services and facilities.

The addition of 300 housing units, of which 200 are expected to be single family residences, would have a positive long-term effect on the assessed valuation of the cities of Ketchikan and Saxman and the borough. Based on an average market value of $110,000 per unit (1983 dollars) the total project-related housing would have a market value of $33 million. Assuming that 80 percent of the units were located within the city and 20 percent located outside the city, the total tax reserve based on the differing mill levies in the city and borough would be about $255,000 in 1990 (1983 dollars).

4.3.1.5 Phase-In Townsite Option

The phase-in townsite option would involve the same mine construction and operations work force and schedule as the proposed project. Townsite construction would begin in year 1 and take 4 years to complete. The preoperations and operations personnel would reside in Ketchikan from year -2 to year 4. Over a 2.5-year period, the Quartz Hill personnel would move in phases to the permanent townsite. The move to the townsite would be completed by year 4.

Employment

Direct employment would consist of persons working on construction and operations at the mine site, construction at the townsite, and at the U.S. Borax office in Ketchikan. The work force requirements for mine construction and operations and at the Ketchikan office would be the same as for the commute option. The townsite would require about 100 workers for a 4-year period.

Indirect employment would involve the same types of jobs and would be in the same ratio to direct employment as the proposed project.

During peak construction, the Quartz Hill project would directly employ about 1,280 persons. At that time, there would also be about 500 persons indirectly employed. By the year 2000, direct permanent operations employment and indirect employment would each decrease to approximately 1,000 persons. Thus, the Quartz Hill project would result in a long-term employment effect of approximately 2,000 persons, the same as for the other options.

The distribution of employment benefits among the local and nonlocal populations is presented in Table 4-35. Employment by local residents would represent 20 percent of total employment during peak construction and 43 percent of total employment by year 2000.

In comparing the with-project employment forecasts to baseline employment forecasts, the results indicate that the project would accelerate the growth in jobs by 13 years. The number of jobs in year 2000 under baseline conditions would be approached in year -2 under the commute option.

TABLE 4-35

DIRECT AND INDIRECT JOBS CREATED
BY QUARTZ HILL PROJECT

PHASE-IN TOWNSITE OPTION

Project Year	Local Direct	Local Indirect	Local Total	Nonlocal Direct	Nonlocal Indirect	Nonlocal Total	Grand Total
-4	8	8	16	72	19	91	107
-3	50	51	101	432	120	552	653
-2	148	152	300	1134	355	1489	1789
-1	137	136	273	414	315	729	1002
1	223	220	443	588	511	1099	1542
2	247	242	489	644	567	1211	1700
3	247	245	492	662	572	1234	1726
4	294	290	584	828	676	1504	2088
5	294	288	582	686	672	1358	1940
6	294	288	582	686	672	1358	1940
7	297	291	588	694	681	1375	1963
8	294	288	582	686	672	1358	1940
9	294	288	582	686	672	1358	1940
10	297	291	588	694	681	1375	1963
11	297	291	588	694	681	1375	1963
12	297	291	588	694	681	1375	1963

Personal Income

The impacts of the Quartz Hill project would be the same under the phase-in townsite option as with the proposed project.

Local and Regional Business Activity

The population increase in the Ketchikan Gateway Borough and at Quartz Hill would generate an increase in volume of new business for area firms. Local businesses would expand their inventories to supply goods and services directly to Quartz Hill and/or to serve the needs of additional residents. The types of impacts that could occur under the phase-in townsite option would be similar to the impacts expected under the commute option.

Population

Average annual population growth in the Ketchikan Gateway Borough with the Quartz Hill project would be 3.7 percent during the year -4 to year 2 period, -0.2 percent during the year 2 to year 7 period, and 1.0 percent during the year 7 to year 17 period. This compares to average annual growth rates of 1.2 percent, 1.2 percent, and 1.1 percent for those periods, respectively. These with-project growth rates, as compared to baseline growth rates, are presented in Table 4-36.

A rapid period of population growth would occur from year -3 to year 2 in order to support start-up of the mine. The operations work force and their families would be living in Ketchikan. Local jobs vacated by Ketchikan residents for construction jobs at Quartz Hill would be another factor contributing to the population influx. Population in the Ketchikan Gateway Borough would increase by 1,900 persons over that 5-year period. The project-induced population would reach a peak of about 1,950 at the end of year 2. Total population would stabilize at about 18,000 persons between year 2 and year 9 because the out-migration of workers to the Quartz Hill townsite would be offset by growth in the baseline population. The number of newcomers would decrease to about 800 in year 6, at which time all operations personnel would have moved to the permanent townsite. The project-induced population would stabilize at 800 persons for the life of the mine. Despite the out-migration of Quartz Hill workers, total Ketchikan Gateway Borough population would never experience decline due to the secondary population effects of Quartz Hill and normal baseline population growth.

The population of the townsite would start out at about 50 in year 3. Between year 3 and year 7, the population would increase to about 1,950 persons. The ultimate population expected at the townsite, including operations and secondary workers and their families, would be about 2,000.

TABLE 4-36

POPULATION IMPACTS IN
KETCHIKAN GATEWAY BOROUGH

PHASE-IN TOWNSITE

Project Year	Baseline	Baseline and Quartz Hill (excluding speculative in-migrants)	Baseline and Quartz Hill (including speculative in-migrants)
-4	14,920	14,968	14,993
2	15,900	17,844	18,214
7	16,944	17,717	18,141
12	18,057	18,829	19,253
17	18,759	19,557	19,989

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In comparing the with- and without-Quartz Hill population projections for the Ketchikan Gateway Borough, the estimates indicate that the project would accelerate population growth by about 4 years. The baseline population of 18,759 in year 15 is comparable to the with-project population in year 11. Total population in the Ketchikan Gateway Borough in year 15, including the effects of Quartz Hill, would be 19,544. If the effects of the presence of speculative in-migrants are taken into account, the project would accelerate growth by an additional year.

Regional population impacts would be similar to those discussed for the proposed project.

Housing and Land Use

The result of the population influx into the Ketchikan Gateway Borough would be a requirement of nearly 300 permanent and 400 temporary housing units by year 2. The large number of temporary housing units would be needed to accommodate the operations and support workers and their families before they moved to the permanent townsite. After year 2, no additional housing units would be required. Some of the vacated units could be used to house baseline growth, but there would nevertheless be a substantial number of excess temporary housing units. The housing requirements by type of unit are provided in Table 4-37.

TABLE 4-37

HOUSING REQUIREMENTS DUE TO QUARTZ HILL PROJECT
BY TYPE OF UNIT
(Number of Units)

PHASE-IN TOWNSITE OPTION

Project Year	Single Family	Multi-Family	Mobile Home	Total	Number of Housing Starts
-3	50	50	10	110	110
-2	150	100	100	350	240
-1	200	100	130	430	80
1	200	100	330	630	200
2	200	100	-	300	-330
7	200	100	-	300	0
12	200	100	-	300	0
17	200	100	-	300	0

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Most of the housing impacts would occur during the year -4 to year 3 period, stemming from the need to provide a very large number of units in a short time. The short-term housing needs of the operations workers could be met through the provision of mobile homes. The fluctuations in demand for housing between year 1 and year 20 could cause vacancies with respect to mobile homes. The movement of people from the Ketchikan Gateway Borough to the permanent townsite would result in a high vacancy rate unless mobile homes could be used to effectively accommodate the interim Quartz Hill population or be moved to the new townsite. The vacancies could occur among other housing types and this type of impact would be difficult to control.

The types of impacts on housing supply and prices mentioned under the commute option would be expected to occur under the phase-in townsite option. The impacts would be short term and no impacts due to Quartz Hill would occur beyond year -2 if the large number of mobile homes could be dismantled.

Public Services and Facilities

Despite the temporary influx of Quartz Hill workers into the Ketchikan Gateway Borough, the subsequent out-migration would not cause services and facilities to be left with excess capacity. The total population of the Ketchikan Gateway Borough would stabilize at about 18,000 persons between year 2 and year 9 because the out-migration of workers to the Quartz Hill townsite would be offset by growth in the baseline population. As a result of baseline population growth, the total Ketchikan Gateway Borough population would never experience a decline.

The temporary influx of Quartz Hill-related population would have the effect of accelerating the need to expand some of the public services and facilities. The long-term needs for expansions would be similar to the townsite option after year 6. Prior to year 6, however, the interim needs would be greater than for the townsite option because of the larger project-induced population. The interim period has been defined as year -2 to year 5. Some of the interim needs could be met through the use of temporary school classrooms, for example. The assessment of impacts on public services and facilities attributable to Quartz Hill does not take into account the needs of future baseline population growth. In the example of providing temporary classrooms to meet the interim needs, it is possible that the out-migration of Quartz Hill population would coincide with the growing needs of the permanent baseline population. In that case, the provision of permanent classrooms could be more appropriate than temporary classrooms. The costs of constructing permanent classrooms could not, however, be attributed to the Quartz Hill project.

The impacts of the Ketchikan population related to Quartz Hill are discussed only for those services and facilities that would be impacted by the phase-in townsite option.

Solid Waste - The project-induced population would not have any impact on the planned incineration capabilities of Ketchikan. The planned incinerator would be sufficient under the phase-in townsite option until after year 20.

Based on a long-range estimate of an additional 190 new accounts for solid waste collection, beginning in year 2, the Department of Public Works would need an additional staff person to work 20 hours per week. The cost of hiring an additional sanitation worker one-half time would be about $12,200 per year (1983 dollars) (City of Ketchikan 1983).

The interim needs would be collection of solid waste for an additional 400 housing units, which would most likely be mobile homes. The impact of these units on the Department of Public Works would depend upon their location. Assuming that these temporary housing units would be served by the City of Ketchikan, an additional person would be needed one-half time at a cost of $18,200 per year (1983 dollars) (City of Ketchikan 1983).

Street Maintenance - The project-induced population of about 800 would require one to two additional staff to maintain streets. This estimate is based on two alternative methods of calculating impacts as described in the commute option.

Transportation - In evaluating the impacts of additional traffic on Tongass Avenue, the number of vehicles that would be present in Ketchikan in 1990 was considered, as that year represents a period of peak project-induced population. The operations workers were not included in the total population as they would be in Ketchikan only on weekends when the traffic problem is not as great. The project-induced population would own an estimated 792 vehicles, representing a 21 percent increase from the present conditions.

A very small increase in vehicle traffic would occur outside the City of Ketchikan because of Quartz Hill. Assuming the proportion of population in unincorporated areas (0.40) does not change significantly from 1983 and that 20 percent of the above 792 vehicles (158 vehicles) would be located in the same area, a 2.8 percent project-induced increase would occur in the number of vehicles in unincorporated areas. This would be a negligible increase and impact above baseline conditions, although the Department of Transportation is presently severely understaffed (Schalep 1987).

The ferry that serves the airport is currently operating at capacity. The addition of 2,800 persons related to the Quartz Hill project located both in the KGB and at the site could necessitate an additional ferry or a larger ferry to replace the existing one.

Demand for commercial flights would increase as a result of the economic activity associated with the Quartz Hill project, with possible resultant benefit of expanded service and more competition among air carriers.

Ports and Harbors - A total of 1,550 slips would be needed under the phase-in townsite option in year 11, as opposed to 1,485 under the baseline conditions in the same year. The costs associated with providing moorage for the additional population in year 11 would be $1.30 million (1983 dollars).

During the peak period of Quartz Hill-related population, a maximum of 160 additional boats could be present in Ketchikan. This demand could cause a strain on the capacity of the open moorage area, resulting in the need to expand that capacity.

Library and Museum - The long-term impacts on the library and museum would be the same as for the townsite option.

The interim needs during the peak period of Quartz Hill-related population would be one full-time person each at the library and museum.

Recreation - Projections of recreational facilities and staff requirements under baseline and with-Quartz Hill conditions are presented in Table 4-38. The estimates of athletic and indoor facility needs show that the current inadequacy of facilities is greater than the project-related incremental requirements over the next five years. The recreational requirements of the project-induced population would be playing fields, tennis court, and a neighborhood park. Based on the planning standard of 1.03 staff/1,000 population, 1 staff person would be needed to meet the long-term project-related requirements and 2 persons during the interim period. The cost of staff to the city would be $34,300 and $68,600, respectively (1983 dollars) (City of Ketchikan 1983).

Education - The phase-in townsite option would have impacts on both the Southeast Islands School District and the Ketchikan Gateway Borough School District (KGBSD). The impacts on the SEISD were discussed under the townsite option.

The KGBSD would be impacted from an interim peak project-induced population of 1,950 and permanent population influx of 800. The estimated number of school children and teacher requirements are presented in Table 4-39. These estimates indicate that the project-induced school enrollment would increase to 500 in the year 2 school year and decrease to 200 in the year 7 school year, leveling off at that point. These interim requirements could be met most effectively through temporary modular classrooms rather than through the construction of permanent classrooms. The long-term increase of 110 elementary students attributed to Quartz Hill would exceed the elementary school capacity unless White Cliff School were to remain open. While a new elementary school would be needed after year 1 under baseline conditions, the Quartz Hill related population would comprise 1/3 of capacity of the school. The Schoenbar Junior High and Ketchikan High schools would have the capacity sufficient to accommodate the 30 junior high and 60 high school students.

The construction cost of a new 350-student elementary school would be approximately $10 million (1983 dollars) (Ketchikan Gateway Borough School District 1983, p. 28). The cost attributed to Quartz Hill school enrollment impacts would be $3.3 million. The lead time required for constructing a school of this size would be from 1 to 2 years.

TABLE 4-38

COMPARISON OF RECREATIONAL FACILITY REQUIREMENTS
BASELINE AND WITH QUARTZ HILL
PHASE-IN TOWNSITE OPTION

(Number of Facilities)

Facility	Standard (Population)	Baseline Year 1	Baseline Year 6	Quartz Hill Year 1	Quartz Hill Year 6
Athletic Facilities:					
Softball Diamonds*	1/3,000	5	5	5	5
Baseball, T Ball*	1/12,000	1	1	1	1
Baseball, Little League*	1/6,000	2	2	3	3
Baseball, Senior League*	1/12,000	1	1	1	1
Football Field*	1/6,000	2	2	3	3
Soccer Field*	1/6,000	2	2	3	3
Track Field	1/12,000	1	1	1	1
Tennis Courts	1/2,000	7	8	8	8
Outdoor Basketball	1/1,500	11	11	11	11
Indoor Facilities:					
Gymnasiums	1/1,500	10	11	11	11
Tennis Courts	1/6,000	2	2	3	3
Handball/Raquetball	1/3,000	5	5	5	5
Pools	1/6,000	2	2	2	2
Recreation Center	1/12,000	1	1	1	1
Neighborhood Park	1/1,750	9	9	10	10
Regional Park	1/4,500	3	3	3	3
Community Park	1/8,000	2	2	2	2

* Note: These facilities are not available at all times for a specific type of activity.

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TABLE 4-39

ESTIMATED NUMBER OF SCHOOL CHILDREN
RELATED TO QUARTZ HILL POPULATION
PHASE-IN TOWNSITE OPTION

Project Year	Elementary	Junior High	High	Total	Number of Teachers 1/
-3	22	6	13	41	3
-2	143	40	82	265	18
-1	136	37	78	251	17
1	244	69	140	451	31
2	270	75	155	500	35
3	249	69	142	462	32
4	237	65	136	438	30
5	183	50	105	338	23
7	107	30	61	198	14
13	107	30	61	198	14

1/ Based on pupil-teacher ratio of 14.2 (Van Wechel 1984).

Social Services - The impacts of the project-induced population on social service agencies are difficult to predict. With the phase-in townsite option, the period of rapid growth would be from year -2 to year 2. During this time the number of caseloads could increase disproportionately to the increase in population. The types of impacts that could occur during this period are discussed under the proposed project. After year 2 the number of caseloads would probably increase in proportion to population growth. At the townsite, a permanent or itinerant mental health and substance abuse worker would be required to serve the needs of that population because the townsite would fall within the program's catchment area.

Law Enforcement - The long-term needs for the Ketchikan Police Department would be to hire 2.5 officers by year 7 at an annual cost to the city of $124,000 (1983 dollars) (City of Ketchikan 1983). During the rapid growth period of year -3 to year 2, the short-term needs to handle the interim population would be to hire 6 additional police officers.

Fire Protection - The project-induced population is expected to reside in mobile home parks and in new subdivisions. These housing developments would probably be located on the edge of the city limits to take advantage of city sewer and water facilities. The impacts of this population would be similar to those discussed under the townsite option. The prevalence of mobile homes could cause additional impacts as discussed under the proposed project.

Public Finance

The impacts on the city and borough to finance public projects would be greater than for the townsite option. The relatively small tax base due to the use of mobile homes rather than permanent housing and the high interim costs associated with providing additional capacity in the schools would be the two major contributing factors to the greater financial impact. The uncertainty of the timing of the townsite and the relocation of persons from Ketchikan to the permanent townsite could result in reluctance on the part of the permanent residents to commit to financing the needed public expenditures.

4.3.2 State and National Economics

4.3.2.1 The State Economy

The fiscal impact of the Quartz Hill project on the State of Alaska will be a function of state revenues and state expenditures generated by the project. Both will be directly affected by state taxation and spending policies, which are expected to be related to changes in the revenue from Alaska North Slope oil. Projections of state fiscal impact based on the state's current tax structure and spending habits should therefore be used cautiously, with attention to the factors independent of the project that could affect its fiscal impact on the state.

Revenues

State tax revenue directly from U.S. Borax operations will come from three sources: the Alaska corporate income tax, with a rate rising to 9.4 percent of taxable income over $90,000; the Alaska minimum tax, which equals 18 percent of the federal minimum tax; and the Alaska mining license tax, with a rate rising to 7 percent of net income over $90,000. Over the first 24 years of project life (4 years of development plus 20 years of operation), the combined total of the three taxes is estimated at $134 million, an average of $5.6 million per year. Due to start-up costs and other factors, taxes would begin at about $2 million in the fifth year of operation, rise to $12 million in years 14-16, and drop back to $8 million in years 17-20.

Under present Alaska tax laws very little state revenue is generated from individual Alaskans or from small businesses. Based on Alaska Department of Revenue data for fiscal 1983, annual per capita state revenue from taxes and fees paid by households was $72. Assuming a project-induced population of 2,800 persons and no changes in the tax fee structure, the Alaska Office of the Governor (1982a) estimated the annual taxes and fees paid by households and attributable to the project would be in the neighborhood of $180,000. This figure may slightly understate the level of revenue impact associated with the project from taxes and fees paid by households, since per capita personal income in the Ketchikan area has been the second highest in the state (Alaska Department of Labor 1982).

Revenue from households would be higher if the state returns to the tax policies of the late 1970s. During fiscal 1979, state taxes and fees paid by individuals averaged $445 per capita in 1983 dollars. Using this figure suggests that annual revenue from households resulting from the project would be roughly $1.1 million if the earlier tax structure is readopted. The Office of the Governor estimated that reinstitution of the state personal income tax at the rates pertaining in 1978 would annually result in an additional $850,000 attributable to the project. Because the state's figure does not include revenue from other taxes and fees paid by households, the two estimates should probably be considered equivalent.

The Alaska Office of the Governor (1982a) has estimated that corporate income taxes paid by Alaska firms doing business with U.S. Borax will result in an additional $100,000 annually in revenue attributable to the project, or $40 per capita if measured against the estimated population increase of 2,500 people expected to be associated with the Quartz Hill development. In fiscal 1983, nonpetroleum state corporate income tax collections throughout Alaska averaged $65 per capita (Alaska Department of Revenue 1983a). Given the relationship between corporate income taxes paid by support sector and basic sector corporations (Alaska Department of Revenue 1983b), the $40 per capita estimate appears reasonable.

Expenditures

Previous estimates of the Quartz Hill project's anticipated impact on state (Alaska Office of the Governor 1982a) and local (NISR 1983; Entercom 1982a; Gee and Carssow 1981) expenditures have been based on

the projections of current average per capita government expenditures together with estimates of the additional population resulting from the project. However, the statistical record of state budgets and population over the 22-year period ending with fiscal 1983 reveals no consistent relationship between population changes and current or later changes in the state budget (Appendix J).

During the first few years of project operation when the company tax liability will be low, the cost of providing current state services to the population attracted by the project may exceed additional tax revenues. The imbalance would create additional competition for limited state resources, and lead to a dilution of per capita benefits of state spending. The magnitude of this dilution, if spread evenly over programs and regions, would be very minor. State spending in Alaska is $6,500 per capita, roughly 275 percent higher than in any other state (Council of State Governments 1982). The addition of 2,800 people as a result of the project would reduce statewide per capita spending by less than one-half of one percent. Therefore, over the long term, state expenditures and revenues attributable to the project are expected to be roughly equal (Alaska Office of the Governor 1982a).

Other Statewide Economic Impacts

Opening of the Quartz Hill mining operation in Alaska would expand the state's economic base and reduce the seasonality of employment patterns. It would contribute to the state's goal to diversify the Alaskan economy. As the first large nonprecious metallic mineral mine in the state, it would, if economically successful, stimulate investor interest in the development of other mineral resources elsewhere in Alaska.

Mining, particularly metal mining, tends to be less industrially stable than the economy as a whole. Recent suspensions of molybdenum mining operations in other states have caused major problems in the communities affected, and have reduced employment in molybdenum mining by 73 percent in the span of one year (Bureau of Mines 1983). This instability could have adverse effects on the state's economy and fiscal situation. The temporary shutdown alternative, for example, would result in the state's continuing to pay for many services for the project-related population, while tax revenue from the project would be lost during the shutdown.

4.3.2.2 National Fiscal and Economic Effects

The most significant national economic effect from operation of the Quartz Hill mine is likely to be its positive impact on the nation's international trade. Production from Quartz Hill might have a negative impact on the existing molybdenum mining industry in the U.S if the additional molybdenum supply brings prices down. Lower prices are favorable for molybdenum buyers, however. The extent to which these impacts materialize would depend on long-term developments in molybdenum production and demand, both in the U.S. and abroad.

Historically, the U.S. has been the world's major supplier of molybdenum. Since 1962, U.S. exports have climbed from 30 percent of U.S. production to 60 percent in 1982 (Appendix J). Since 1978, much of the domestic production that was not exported was added to stocks (Bureau of Mines 1983); by 1982, U.S. output of molybdenum was 217 percent of U.S. consumption (Appendix J). Because U.S. self-sufficiency is expected to continue for the foreseeable future, no stockpiles of molybdenum are currently maintained by the U.S. government (Bureau of Mines 1982).

U.S. demand for molybdenum declined by 49 percent between 1979 and 1982. The worldwide recession, and its severe effects on the energy and capital goods sectors, appears to have been at least partly responsible. This trend may reflect the relative decline in the "smokestack" industries where molybdenum finds its major markets. Renewed growth in the capital goods sector can be expected to at least slow the trend, if not reverse it.

Forecasters had been projecting domestic demand for molybdenum to increase through the 1980s at an average annual rate of 3.1 to 4.2 percent (Chase Econometrics 1981; Bureau of Mines 1983). However, U.S. consumption fell a further 22 percent in the first eight months of 1983 compared with the same period in 1982 (Metals Week 1983). More recent forecasts predict that 1984 world demand will not exceed 120 million pounds, a compound annual rate of decline of more than 11 percent since the peak year of 1979 (Metals Week 1983).

Depending on the rate of economic recovery, growth in domestic consumption may or may not be sufficient to absorb major additions to U.S. output. Production of 80,000 tons per day of ore from the Quartz Hill mine would add 46 million pounds of molybdenum to average annual U.S. output. The Quartz Hill molybdenum would equal 141 percent of the low U.S. consumption in 1982, or 63 percent of the high U.S. consumption in 1979 (see Appendix L). The capacity of domestic industry to absorb additional molybdenum production depends on the overall level of economic recovery.

If the output of the mine is exported and does not displace other domestic output, it will positively contribute to the U.S. balance of trade. The amount of this contribution will depend on molybdenum prices. Between 1940 and 1975, the real price of molybdenum (in 1982 dollars) remained relatively stable between $4 and $6 per pound (Appendix J). By 1979, however, the price had reached an all time high of $22 per pound in dealer quotes. In 1980 and later, real prices fell back to their historic levels. It is not possible to reliably predict the future trend of molybdenum prices. However, at $5 per pound, exports from the 80,000 tpd Quartz Hill operation would add about $267 million annually to the nation's balance of trade. At a higher estimated price of $6.70 (Alaska Office of the Governor 1982b) the contribution would be $357 million.

Capital costs for the Quartz Hill mine operations for the first 20 years have been estimated at over $700 million (U.S. Borax 1984). Rio Tinto-Zinc, the parent company of U.S. Borax, is a well-capitalized

firm, one of the few in the world mining industry to have been consistently profitable over the last four years (Rio Tinto-Zinc 1981; Mining Journal 1983). Although it is possible that such a firm might undertake to open a mine as large as Quartz Hill and later be forced to abandon it, such an event seems very unlikely. It is possible, however, that a mine of this magnitude could be shut down for extended periods due to adverse market conditions, as has been the case with other comparable molybdenum mines in the U.S. Despite these possible business fluctuations, the U.S. Department of the Interior, in approving Pacific Coast Molybdenum Company's patent application, has determined that the deposit has the potential of becoming economical under certain market conditions.

4.3.3 Cultural Resources

Much of the project area has been surveyed for cultural resources at a reconnaissance level (Ackerman and Gallison 1981), but only the route of the mine access road has been examined at a detailed level (ERTEC 1982). In the absence of specific knowledge about the locations of all cultural resources within the project area, environmental consequences are evaluated assuming that cultural resources may exist in a particular area (Appendix I). Intensive surveys will be conducted in each area to be directly affected before construction starts in that area. These surveys of specific project sites may reveal that no significant cultural resources are present and, consequently, that an activity would have no significant impact. This determination would be made once specific data are available. If cultural resources were located during the surveys, mitigation measures would be taken to salvage or avoid the site or resource and, thus, reduce the level of impact.

Project impacts have been evaluated according to the probability of the occurrence of cultural resources as well as the magnitude, extent, and duration of the impacts upon cultural resources. The project area was divided into environmental/topographic zones of differential probability for containing cultural resources. High probability zones include stream mouths, floodplains, the intertidal zone, other coastal zones of less than 60 percent slope, and late Pleistocene to early Holocene marine deposits. Moderate probability zones include portions of the coast of greater than 60 percent slope, inland stream crossings and river valleys, and forested valley sideslopes of less than 60 percent slope. Low probability zones include tideflats, inland hillsides of greater than 60 percent slope, and muskegs.

Nearly all construction activities are considered to be of major magnitude because any activity that disturbs the ground's surface at the site of a cultural resource would cause some irreversible damage to that resource. A ground disturbing activity can destroy all or a significant portion of a cultural resource. Indirect disturbances caused by increased population or access to an area are generally diffuse and, therefore, have been considered of medium to small areal extent. All damage to cultural resources encountered by construction activities would be irreversible.

4.3.3.1 No Action

Cultural resources would remain unaffected provided no additional areas are disturbed.

4.3.3.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

Most project impacts would occur during the construction period. Cultural resources, if located in the mine pit area, would be on the surface or in the overburden and would be revealed when the overburden is stripped from the site. The probability of cultural resources existing in the mine area and the muskeg covered portions of Bear Meadow is low; their probability in forested or well drained portions of Bear Meadow is moderate.

Surface disturbance associated with construction at the mine service area and crusher sites would reveal cultural resources present. No cultural resources were found in an intensive survey of the 100-ft-wide access road corridor near the facility sites, but the sites themselves have not been intensively surveyed (ERTEC 1982). The probability of cultural resources is moderate.

The use of the waste rock disposal area and sedimentation ponds would begin in the construction period, but their heaviest use would not occur until the mining period. Unrecovered surface cultural resources in those locations need to be salvaged or otherwise mitigated. Subsurface resources in waste rock disposal areas would theoretically be protected by being more deeply buried, but practically speaking, the information they contain would become irretrievable. Subsurface resources in the sedimentation ponds would need to be mitigated due to fluctuating water levels or periodic dredging. The probability of cultural resources in the forested or well drained portions of North Meadow and the White Creek, North Creek, and Beaver Creek drainages is moderate; the probability in muskeg covered portions of these areas and the entire Hill Creek drainage is low.

The ore transport line would run through an area of low cultural resource potential and would be entirely within a bedrock tunnel. Its construction should cause no disturbance of cultural resources other than at the portals, which are included in the sites of the crusher and mill.

The probability of cultural resources at the mill site is moderate and these would become revealed during construction.

Construction of the dam for the reservoir on Tunnel Creek would reveal any cultural resources present. The effects of filling the reservoir could be insignificant or even beneficial for subsurface resources if the water level remains fairly constant, but practically speaking, the resource would become irretrievable for the life of the reservoir. The probability of cultural resources in the reservoir area is moderate. Construction of the access road to the Blossom River supplemental water supply would reveal any cultural resources present. The probability of

cultural resources in the general area of the road is high. The south end of the road corridor may pass through the reported site of six smokehouses, a potentially significant cultural resource.

The tailings disposal line would run through an area of low cultural resource potential. With the exception of its portals at Tunnel Creek, Falsegate Creek, and Boca de Quadra, the line would be entirely within a bedrock tunnel and should not disturb cultural resources. The portals are located in areas of moderate cultural resource probability, and construction there could destroy any resources present. The dock and support facilities on Boca de Quadra are in an area of high to moderate cultural resource potential.

Construction of access roads would reveal any cultural resources within the right-of-way. Cultural resources located atop sand and gravel sources needed for the roads would also be endangered. The mill and Boca de Quadra access roads pass through areas of high to moderate cultural resource potential. The corridor for the mine access road has already been intensively surveyed for cultural resources. None were found, though the road passes close to two historic sites (ERTEC 1982). The consequences of upgrading the existing access road would be insignificant. Sand and gravel sources have not yet been identified, but likely fall within areas of high to moderate cultural resource potential. Expansion of the existing dock on Wilson Arm to the north would reveal any cultural resources at the site. While the probability of cultural resources in the area is high, none were found in an intensive survey of the area (ERTEC 1982). Helicopter pads are associated with sites of other surface disturbing activities and are not discussed separately.

The potential for cultural resources is high along the shores of Wilson Arm and Boca de Quadra in the vicinity of the proposed construction camps and several potentially significant sites have been documented (Ackerman and Gallison 1981; ERTEC 1982). Floating camps in these waters would create little surface disturbance and thus would not affect cultural resources. The construction of land-based camps at the mill and mine would reveal any cultural resources present. The land-based camps are located in areas of moderate resource potential. A land-based camp may also be constructed at the head of Bakewell Arm, an area high to moderate in resource potential. People occupying any of these camps could accidentally destroy any cultural resources in their recreational pursuits.

The land-based communications facilities would be located primarily in areas of low resource potential. Although the likelihood of the resource occurring in these areas is low, erection of these facilities could reveal any cultural resources present.

Several ongoing activities may uncover cultural resources during the mining period. Overburden would continue to be stripped from the pit area during the first five years of mining. The Quartz Hill mine site, which is low in cultural resource potential, would be the last area stripped. The surface area affected at the waste rock disposal site and sedimentation ponds would increase as the disposal areas are

filled. The expected consequences have been discussed above. The sand and gravel pits may have to be expanded to assure a supply for road repair. This could reveal additional resources in areas of high to moderate potential.

Housing would be in permanent camps at the mill and mine sites and possibly at Tunnel Creek. The potential for accidental damage to cultural resources in the area by residents would continue.

For the postmining period, roads built for the project, even if recontoured, would continue to provide access to the project area for a short time until they are overgrown.

4.3.3.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

The environmental consequences would be similar to those described in Section 4.3.3.2 except with regard to housing workers at a permanent town. All three townsite alternatives, Wilson I, Wilson IIa, and Bakewell are in areas of high to moderate cultural resource potential. Construction of the town and support facilities could reveal any cultural resources present. If the Bakewell site were chosen, a shoreline road connecting it to the wharf on Wilson Arm may be built. The cultural resource potential of the proposed route is high to moderate.

4.3.3.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The environmental consequences would be similar to those described in Section 4.3.3.2 except that the tailings disposal line would run from the mill to Wilson Arm. The pipeline following the mine access road to the wharf would cause a minimal incremental environmental impact. A shoreline service road from the wharf to the outfall would pass through an area of high to moderate resource potential. The housing alternatives are discussed in Section 4.3.3.3.

4.3.3.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

The Beaver Creek mill site is of moderate cultural resource potential. No resources were found in an intensive survey of the nearby road corridor, but the mill site has not been intensively examined (ERTEC 1982). The ore transport line runs through a proposed waste rock disposal area. The environmental consequences of the dump would not be increased by the line. A reservoir may be required on Raspberry Creek. Its effects would be similar to those of the Tunnel Creek reservoir except that the Raspberry Creek area is low in cultural resource potential.

The surface portion of the tailings disposal line is in an area of low resource potential. The resource potential of its coastal portion varies from low along sheer cliffs to high in areas of more moderate slope. Tunnel portals, surface portions of the line, and access roads would reveal any cultural resources present.

4.3.3.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

The environmental consequences would be similar to those in Section 4.3.3.5 except that tailings disposal would be as discussed in Section 4.3.3.4.

4.3.3.7 Beaver Creek Mill with On-Land Tailings Disposal

The environmental consequences would be similar to those in Section 4.3.3.5 except for the tailings disposal line and tailings disposal sites. One tailings disposal line would run overland to Tunnel Creek through an area of low resource potential. The other tailings disposal line would run overland along Hill Creek, Keta River, and Aronitz Creek. Resource potential is low in the Hill Creek valley, but high along the remainder of the route. The effects of tailings disposal in the Tunnel Creek and Aronitz Creek valleys would be similar to those of waste rock disposal areas discussed in Section 4.3.3.2. These areas are of moderate cultural resource potential.

4.3.3.8 North Meadow Mill with Boca de Quadra Tailings Disposal

The cultural resource potential of the crusher, mine service area, and mill sites is moderate. The effects of the reservoir on upper Hill Creek would be similar to those of the Tunnel Creek reservoir. The cultural resource potential of the area is moderate to low. The wharf facility at the mouth of Aronitz Creek is on the reported site of a smokehouse, a potentially significant cultural resource. The Keta townsite is in an area of high resource potential. The environmental consequences of this and any land-based construction camps would be similar to those discussed in Sections 4.3.3.2 and 4.3.3.3.

4.3.3.9 North Meadow Mill with On-Land Tailings Disposal

The environmental consequences would be similar to those described in Section 4.3.3.8 except that the consequences of the tailings disposal lines and tailings disposal sites would be as described in Section 4.3.3.7.

4.3.4 Land Use

4.3.4.1 No Action

If the project were not constructed, dispersed recreation would probably be the primary land use. A major uncertainty associated with this alternative would be the disposition of the patented Quartz Hill claims. U.S. Borax could retain this private property or seek to sell it to another party. Section 503(h) of ANILCA appears to grant identical development rights to any successor in the U.S. Borax interest.

4.3.4.2 Proposed Project and Concept Alternatives

Land ownership effects associated with the proposed project should be negligible. The U.S. Borax mining claims have already become private property through the patenting process, so mine development would not

change land ownership in the project area. It is assumed that lands needed for the mill, mine service area, and other support facilities would be leased to U.S. Borax by the Forest Service, as provided for in Section 503(i) of ANILCA, with the federal government retaining title to the land itself.

Impacts related to land use would stem from the conversion of a large tract of essentially primitive land to industrial development. The facilities included within the proposed action would occupy an actual surface area of approximately 2,000 ac, about half of which would be accounted for by the mine pit. Because project visual effects would generally extend for one mile or more from project facilities, the proposed project would represent the effective dedication of roughly 40,000 to 45,000 ac to industrial land use and associated disturbance. While this area is modest in relation to the entire Monument and the impact on existing land uses would be minor in magnitude, the impact would be moderately significant due to its duration and likelihood.

Tailings disposal directly in the middle basin of Boca de Quadra would require development of land support facilities within the wilderness portion of Misty Fiords National Monument. Lands for these facilities would necessarily be included in the U.S. Borax lease. Section 503(i)(1) of ANILCA provides the holders of the Quartz Hill property with lease entitlements for facilities associated with mining or milling and located within the Monument. The so-called "mining exclusion" of the Wilderness Act also allows for mine development and operations within wilderness areas, subject to reasonable agency regulations and the U.S. mining laws. Development of the tailings disposal support facilities within the Monument wilderness is therefore a permissible use that can be accommodated within the Forest Service lease arrangements, and does not require a wilderness boundary adjustment or other special action.

ANILCA Section 810 - Subsistence Evaluation and Finding

In 1988, a comprehensive subsistence inventory was jointly conducted on the Tongass National Forest by the University of Alaska, Forest Service, and the Alaska Department of Fish and Game to identify and evaluate subsistence uses by communities. This inventory revealed extremely limited use of the project area. Only a minor amount of subsistence deer hunting exists according to the inventory. No other uses were identified. Because of its remote location from any community, difficulty of access, and because the mine workers will not reside at the site, it is unlikely that there would be any significant subsistence uses in the foreseeable future. Nevertheless, the following evaluation was made:

Evaluation

(1) Since there are minimal and insignificant current subsistence uses, the proposed action would have no significant effect. Future potential uses, should they develop, could be affected by the proposed action through limited access and through habitat alteration. However, such alteration would be mitigated as

disclosed in Section 4.4. There would likely be no increased competition for resources by mine workers or their families, as the workers would reside in Ketchikan ratner than at the site.

(2) Since there are minimal and insignificant current subsistence uses, there would be no significant reduction in subsistence uses due to changes in availability of fish and wildlife resources caused by an alteration in migration or location. While the open pit mine and related mine activity would displace habitat and cause localized change in migration of wildlife, such change in migration would be highly localized and insignificant to potential future uses. Loss of upland habitat would be mitigated as described in Section 4.4 of this EIS. Anadromous fish habitat and productivity would not be significantly affected.

(3) Since there are minimal and insignificant current subsistence uses, there would be no reductions due to access limitations caused by the proposed action. Future potential subsistence uses would likely be restricted at or adjacent to the mine site through habitat alteration and for safety reasons. Such restrictions would not be significant.

(4) There are no other lands available on which the mine could occur. Unlike most land use activities, mining depends entirely on the resource being discovered in sufficient quantities to develop and cannot be scheduled or placed in the most desired location or, in fact, in any other location unless in the unlikely event two similar such discoveries were made.

(5) Alternatives which would reduce or eliminate the effects of the proposed action are disclosed in Chapter 2.0 of this EIS.

Finding

This evaluation concludes with the finding that the proposed action would not restrict current subsistence uses in the project area. This evaluation further concludes that the proposed action will not significantly restrict any potential future uses.

4.3.4.3 Support Facility Alternatives

Townsite or Phase-In Housing Option

Development of a townsite to serve the Quartz Hill population would likely create the impetus for transfer of this land to the residents of the town (although this would conflict with the terms of a townsite lease), as they would probably prefer to own property rather than lease it (U.S. Borax 1983a, p. 5-24). A land exchange or other special transaction would be required for the townsite to enter into private ownership. This should be explored if one of the townsite concepts is preferred. The potential creation of such a strategically important inholding must be considered a moderately significant impact.

Development of a townsite would increase by about 200 ac the overall land requirements of mine development. Selection of the Keta or either Wilson townsite would involve relatively small additions to the land area subject to direct project effects, as these sites are generally close to other project facilities. Development of the Bakewell site would substantially increase the distribution of noise, visual, and other effects, and would increase by about 5,000 to 8,000 ac the area affected by the project. This increase would represent a moderately significant impact.

The cumulative effects of townsite development would be more important, due to the long-range implications of having a community equivalent in size to Wrangell situated in the middle of the Monument. One result of the townsite would be to distribute resident recreational use over a large portion of the Monument. The community would generate a large volume of boat and plane traffic and make Smeaton Bay and lower Behm Canal a commercial travelway. Unless the Forest Service retained very tight control over permitted uses at the townsite, the town could be developed industrially and commercially, which would be in further direct conflict with the purposes of the Monument.

If a townsite option were selected, a separate application would be required for the special use permit for the town (Johnson et al. 1983). An environmental assessment (EA) would probably be prepared as part of the townsite application. The key parameters, such as land ownership and governmental authority, that would be the primary determinants of eventual land use impacts would be identified in that document.

The actual impact of the cumulative land use effects identified above would be on land management. Regardless of the townsite ownership and management policies, dispersed recreational use from the townsite would possibly create pressure to change or amend the wilderness designation (Forest Service 1981a, p. 6-9). Further, certain demands for nearby developed outdoor recreation facilities, firewood cutting, and similar local uses would probably lead to pressure to delete at least a portion of the nonwilderness area from the Monument, or change its management prescription to a more developed level. Given the potential magnitude and extent of such cumulative effects, townsite development would result in very significant land use impacts.

4.3.4.4 Possible Conflicts with Land Use Plans and Policies

Possible conflicts between the proposed project, or its alternative concepts, and the objectives of federal, state, and local land use plans, policies, and controls are explicitly or implicitly addressed in numerous places in this EIS. They are concentrated primarily in Section 4.0 in the discussions of consequences on each environmental resource.

The possible conflicts between mining and wilderness values and a discussion on compliance with the federal Coastal Zone Management Act of 1972 are presented below.

Mining Versus Wilderness Values

The Alaska National Interest Lands Conservation Act, Public Law 96-487, Section 503(f)(2)(A) states that:

> . . . any person who is the holder of any valid mining claim on public lands within the boundaries of the Monuments, shall be permitted to carry out activities related to the exercise of rights under such claim in accordance with reasonable regulations promulgated by the Secretary to assure that such activities are compatible to the maximum extent feasible, with the purposes for which the Monuments were established.

Therefore, ANILCA recognizes existing mining rights while, at the same time, requiring that activities be compatible with Monument purpose to the maximum extent feasible. Maximum compatibility, to the extent feasible, as well as the protection of valid and existing rights, will be the primary criteria upon which decisions will be based relative to the selection of preferred alternatives for this project. Additional relevant legal requirements are contained in the 1872 Mining Law, which gives the prospector and miner the statutory right to enter the National Forests for the express purposes of prospecting and mining. This right cannot be unreasonably restricted. The 1897 Organic Act provides further that persons entering the National Forests for purposes of prospecting, locating, and developing mineral resources under the 1872 Mining Law must comply with rules and regulations covering the National Forests.

Assessment of maximum compatibility with respect to tailings disposal directly in the middle basin of Boca de Quadra differs from other alternatives and options in that it involves a tradeoff between wilderness infringement and other environmental effects; other project options would not require physical development within the wilderness portion of the Monument. Development of support facilities for direct middle basin disposal would be legally permissible, although, other things being equal, disposal options that did not infringe on the wilderness would be preferable.

Coastal Zone Management

The federal Coastal Zone Management Act (CZMA) of 1972, as amended, requires all federal agencies to exercise their authority in a manner consistent with approved state coastal management programs to the maximum extent practicable (CZMA, Section 307[c]). Although federal lands are excluded from the states' coastal zone boundaries, federal agencies are still required to comply with the consistency provisions of Section 307 (CZMA) when federal actions on these lands have spillover impacts that significantly affect coastal zone areas, uses, and resources of the state (15 CFR 923.33).

The Alaska Coastal Zone Management Act of 1977 establishes the state requirements, which include a consistency determination (Douglas 1983). The Alaska Coastal Zone Management Program (ACMP) contains two

types of standards against which the consistency of proposed actions must be evaluated. One set of standards addresses the program consistency of nine major uses and activities, while the other addresses the effects of proposed actions on specific habitats and resources. A review of the proposed project against these standards is provided below. (Alternative concepts are not reviewed in this evaluation.)

Consistency with Major Uses and Activities - The nine major uses and activities requiring a consistency determination are as follows:

1. Coastal development
2. Geophysical hazard areas
3. Recreation
4. Energy facilities
5. Transportation and utilities
6. Fish and seafood processing
7. Timber harvest and processing
8. Mining and mineral processing
9. Subsistence

Activities included within the proposed project are relevant to items 1, 2, 3, 5, 7, 8, and 9 on the above list. (The energy facilities standard applies only to facilities of greater than local concern; while the standard therefore does not apply to the Quartz Hill on-site power generation, its substantive provisions concerning siting, design, construction, and spill control would be met.)

Standard 6 AAC 80.040 Coastal Development. The standard requires that water-dependent and water-related uses be given priority in coastal development, and that dredging and filling be conducted in accordance with the corresponding federal regulations. The coastal development activities of the proposed project, primarily involving the Wilson Arm marine terminal, would be consistent with this standard (see Section 2.2.7 and Appendix O).

Standard 6 AAC 80.050 Geophysical Hazard Areas. Avalanche, landslide, and other geophysical hazard areas are identified in Section 3.1.9, and siting, design, and construction measures for minimizing property damage and protecting against loss of life are described in Sections 4.1.9 and 4.4.5. By including such measures, the proposed project would be consistent with this standard.

Standard 6 AAC 80.060 Recreation. The recreation standard requires that high priority be given to maintaining or increasing public access to coastal waters. The proposed project would have negligible effect on public access to coastal waters, and would also include recreational areas for the project work force (see Section 4.3.6).

Standard 6 AAC 80.080 Transportation and Utilities. Transportation and utility components of the proposed project would be sited inland from beaches and shorelines, except for water-dependent facilities or where no feasible alternatives exist, and would therefore be consistent with the standard (see Section 2.2.7 and Appendix A).

Standard 6 AAC 80.100 Timber Harvest and Processing. The timber harvest standard requires that commercial harvest activities comply with the provisions of the Alaska Forest Practices Act. The clearing and timber harvesting activities of the proposed project would meet this requirement (see Appendix A).

Standard 6 AAC 80.110 Mining and Mineral Processing. Mining and mineral processing activities in coastal areas must be regulated and must be compatible with other ACMP standards, adjacent uses and activities, statewide and national needs, and applicable district coastal programs. Forest Service regulation of mining and mineral processing, as implemented through permit stipulations and approval of a plan of operations, is consistent with this standard.

Standard 6 AAC 80.120 Subsistence. The subsistence standard requires that subsistence opportunities and usage be formally recognized and given priority in designated subsistence zones, and that potentially adverse impacts on subsistence uses be evaluated before potentially conflicting actions can be authorized. The proposed project would not affect any designated subsistence zones and would not have any significant impacts on subsistence use, and would therefore be consistent with this standard (see Section 4.3.4).

Consistency With Habitats and Resources Standards - The ACMP includes habitat standards for eight specific types of habitats, plus two resource-based standards addressing air, land, and water quality and historic, prehistoric, and archaeological resources. The habitat standards (6 AAC 80.130) apply to the following:

1. Offshore areas
2. Estuaries
3. Wetlands and tideflats
4. Rocky islands and seacliffs
5. Barrier islands and lagoons
6. Exposed high energy coasts
7. Rivers, streams, and lakes
8. Important upland habitat

In addition to specific provisions for each habitat, all of these habitats must be managed to maintain or enhance their biological, physical, and chemical characteristics and life-supporting capability. However, uses and activities that do not conform to these general and specific provisions can be permitted if there is a significant public need for the use or activity, there is no prudent alternative that would conform, and feasible steps to maximize conformance are taken. The proposed Quartz Hill project would adversely affect to varying degrees the characteristics and capability of habitats 1, 2, 3, 4, 7, and 8 above, but would be consistent with the standard through application of the provisions for nonconforming uses and activities. The need for the proposed project is identified in Section 1.1., the lack of conforming alternatives is evident from the impact analyses in Sections 4.1 and 4.2, and measures that would be taken to maximize conformance with the standard are described in Section 4.4.

The air, land, and water quality standard (6 AAC 80.140) incorporates the appropriate regulations and procedures of the Alaska Department of Environmental Conservation into the ACMP. Satisfaction of project-specific air quality and water quality requirements of tne ADEC is presumed in order for appropriate permits to be issued. Some requirements, such as definition of a water-discharge mixing zone, may be subject to negotiation between the ADEC and U.S. Borax. In this way, the proposed project would be consistent with ADEC standards. The historic, prehistoric, and archaeological resources standard (6 AAC 80.150) requires district and appropriate state agencies to identify coastal areas that nave cultural resources significance, and therefore is not directly applicable to the proposed project; measures that would be taken to protect existing or potential cultural resources are described in Section 4.4.11.

ACMP Consistency Conclusions - The proposed project would be fully consistent with the ACMP standards for uses and activities, and conditionally consistent with the habitat and resources standards. Several coastal habitats would unavoidably be adversely affected by the proposed project, but the project would be consistent with the habitat standards through the provisions for nonconforming uses and activities. The proposed project is expected to be consistent with tne air, land, and water quality standards pending negotiations with the Alaska Department of Environmental Conservation.

4.3.5 Wilderness

4.3.5.1 No Action

Wilderness values would not be affected if the project were not developed except for the effects of the bulk sampling road mentioned in the Bulk Sample EIS.

4.3.5.2 Proposed Project and Concept Alternatives

Effects of the project on wilderness values would be very similar for the various project alternatives, with the exception of the direct to middle basin Boca de Quadra tailings disposal alternative and would be moderately significant for most of the separate attributes or value components. Many of these effects are somewhat duplicative of those identified for recreation, due to the importance of human use and benefits in wilderness values.

The proposed project would have a considerable effect on natural processes in the nonwilderness portion of the Monument, but is not likely to affect natural processes in the wilderness. The only possible impact mechanism would appear to be deleterious effects of air pollution on vegetation. This potential effect would probably occur over a medium extent but would not be very noticeable, and was judged to be an unlikely occurrence. Consequently, the effect on natural integrity would be insignificant.

The apparent naturalness of the wilderness would be reduced by the evidence of the project on wilderness lands close to the project area. This would primarily consist of moderate direct effects noticeable by

visitors to this area, for an overall rating of moderately significant. Opportunities for solitude would also be moderately reduced by increased visitation and by noise and visual intrusions from project operations, lights, and traffic. While this impact also received a rating of moderately significant, the effect on opportunities for solitude would be more pronounced and extensive than other effects on wilderness values.

Effects on opportunities for primitive recreation would be insignificant, as the project would be unlikely to have a tangible impact on the diversity of the wilderness or the challenge present. It is possible that increased recreational activity would result in the construction of more man-made facilities, but not to the extent of affecting this value. However, it is conceivable that the wildlife disturbances created directly or indirectly by the project would reduce wildlife populations in localized portions of the wilderness, especially near the project. This represents a moderately significant potential impact to ecological values.

Tailings disposal directly in the middle basin of Boca de Quadra would alter these conclusions somewhat, because, unlike other project alternatives and options, this option would require the construction and operation of project facilities within the wilderness portion of the Monument. Under this option, the portal facilities would be located along the shore of Boca de Quadra approximately 1.5 to 2 mi inside the wilderness boundary. These facilities would have a highly localized but long-term effect on natural integrity within the wilderness. The physical extent of reductions in apparent naturalness within the wilderness would be increased compared to all other options, but the net change would not be sufficient to alter impact ratings; the primary effects on apparent naturalness would still be due to increased visitation and noise and visual intrusion. Tailings disposal in the middle basin of Boca de Quadra would also produce greater wildlife disturbances in the wilderness, but again would not cause an identifiable change in effects on ecological values.

The overall impacts of the proposed project on wilderness values, based on these constituent ratings, would be moderately significant. Some particular values associated with the Misty Fiords wilderness would be noticeably reduced, but not to the point where the logical function of the unit would be impaired. This reduction in values would generally be experienced in the reduced enjoyment of many wilderness visitors. Intuitively, the Monument as a whole would be affected somewhat more than the wilderness because most project effects would not extend to the wilderness. However, because the wilderness is clearly the most significant element of the Monument and the greatest impacts would be geographically confined, overall effects on Monument values would also be moderately significant.

4.3.5.3 Support Facility Alternatives

Townsite or Phase-In Housing Option

Development of a permanent community in the project area would have a much greater effect on wilderness values than the proposed project.

All impacts identified previously for the proposed project would still exist, but the townsite option would add substantial impact increments in three cases. Effects on apparent naturalness would be more widespread, although the level of impact would remain moderately significant, while effects on opportunities for solitude and ecological values would increase to the very significant level.

The incremental effects of the townsite on apparent naturalness would primarily be due to wilderness visitors' perceptions of impacts on natural processes. Natural processes within the wilderness would not be physically affected to any greater extent under the townsite option, because vegetation removal and facility development would still be confined to the nonwilderness area. However, the presence of a sizable community would be very noticeable on nearby wilderness lands where the proposed project would not have significant effects, such as the Bakewell Lake area in the case of the Bakewell townsite. The air and water traffic generated by a community would also disperse evidence of the townsite over a large portion of the Misty Fiords wilderness, and would cause visitors to perceive the area as being much less wild and natural than at present. Because the magnitude of this impact would be moderate rather than major, the overall impact rating would be moderately significant.

Opportunities for solitude would be reduced by both a much higher level of wilderness use and the off-site intrusions created by a community. Increased recreational use attributable to the townsite option would more than double the local use component of Misty Fiords recreation (see Section 4.3.5.3), indicating that overnight users would find it more difficult to find solitude. This effect cannot be fully evaluated without better information on current users' perceptions of, and requirements for, solitude. Further, even with a townsite near Quartz Hill, opportunities for solitude in Misty Fiords would probably remain high relative to many other wilderness areas. Despite these qualifiers, from a mathematical standpoint, the townsite option would clearly cause a sharp reduction in current opportunities for solitude. The location of a townsite would also be a very important factor, as any of the townsites in the Smeaton Bay drainage would enable a wider distribution of use and lead to higher use in the more remote portions of Misty Fiords. The combined effects of this increased use and the noticeable and extensive intrusions created by a townsite would result in very significant impacts to this wilderness value.

The final differential impact associated with the townsite option would be a major potential reduction in ecological values, specifically those related to existing fish and wildlife populations. Fish and wildlife in the Monument could be stressed through a variety of impact mechanisms, including displacement due to the physical disturbances created by the project and increased fishing and hunting pressure due to greater recreational use. The townsite option could make a large incremental contribution to such impacts by greatly increasing the level and extent of disturbance effects associated with air and water traffic and increased human presence (see Section 4.2.4). Barring restrictive measures, it would also more than double the sport harvest pressure on local fish and wildlife populations. While it appears to be only possible (rather than probable) that these effects would occur,

major reduction or displacement of fish and wildlife would remove or diminish one of the major attraction elements of Misty Fiords. The potential reduction in ecological values is therefore considered a very significant impact.

4.3.6 Recreation

4.3.6.1 No Action

Little effect on recreation would result if the mine were not developed. Recreational use of the project area would actually decrease, at least initially, as most of the current users of the nonwilderness area are thought to be project workers and Quartz Hill camp dependents.

4.3.6.2 Proposed Project and Concept Alternatives

Development of the Quartz Hill project would have localized direct effects upon existing recreation and more widespread indirect effects through increased use. The direct effects would primarily involve displacement of recreationists from areas they currently use and diminished recreation experiences as a result of noise and visual exposure to project facilities and activities. Placement of fill material for project facilities would not have any identifiable effect on water-based recreation.

Current recreational use of the project area that would be subject to direct project effects appears to range up to 2,200 recreation visitor-days (RVDs), based upon preliminary Recreation Information Management (RIM) data for fiscal 1983. Dispersed use of rivers and streams, saltwater, and general undeveloped areas within the Monument nonwilderness area was reported at about 5,450 RVDs for FY 1983 (Barber 1983b). This figure included about 3,000 RVDs in general undeveloped areas and 250 RVDs at rivers and streams, almost all of which is attributed to the Quartz Hill work force, and 2,200 saltwater RVDs. This saltwater use estimate should be viewed with caution because the percentage of boaters visiting Smeaton Bay and Boca de Quadra who travel to the upper reaches of these fjords is unknown. Consequently, the 2,200 saltwater RVDs should be interpreted as the maximum estimate of local use most likely to be displaced or reduced in quality by the development of the project.

Responses from the Alaska Public Survey indicate that approximately 60 to 80 percent of southeast Alaska recreationists would be adversely affected by the introduction of mine tailings, clearcuts, new buildings, or most other development activities in their favorite recreation areas (Alves 1980, p. IV-35; Clark and Johnson 1981, pp. 104-109). While none of the development examples presented to the APS respondents perfectly represents mine development, it is reasonable to assume that at least 70 percent of Wilson Arm/upper Boca de Quadra users would be negatively affected by mine development sights and sounds. Further application of the APS data indicates that about 40 percent might stop going to the area, while 30 percent (the remainder of those adversely affected) would continue to use the area but at a reduced level of enjoyment.

Applying these percentages to the previous estimate of project area use yields a maximum figure of 880 RVDs displaced by the project and 660 RVDs of reduced experience value. In actuality, the displacement percentage would probably be higher than 40 percent, particularly in the more heavily affected upper Smeaton Bay area, because Ketchikan residents indicated that satisfactory alternate sites with similar attributes were readily available (Clark and Johnson 1981, p. 111). Due to this presumed availability of unaffected alternate sites and the low level of use involved, the displacement and value-reducing effects on recreation in the immediate project area are considered to be insignificant.

Direct effects would also occur in areas that are adjacent to, or even somewhat removed from, the project area. One such direct effect would be exposure of boaters and other recreationists in Smeaton Bay and lower Behm Canal to commercial traffic. Ketchikan area recreationists are less sensitive to the presence of commercial traffic according to their APS responses, as 42 percent reported their favorite site would be less attractive with commercial shipping present and 38 percent responded similarly for aircraft (Clark and Johnson 1981, pp. 106-109). Although these figures are substantial and the affected areas are within the Monument wilderness, the magnitude of impact would be moderated by the expected frequency of such traffic. Aircraft traffic between Ketchikan and Wilson Arm is currently estimated at 4 round trips per day, and operations phase shipping (ferry and barge or tanker) traffic has been estimated at up to 284 trips per year, or 1 trip every 1.3 days. The average boating visit to Misty Fiords is about 3 days in length, although boaters tend to visit more than one location within the Monument. Boaters spending 1 day or more in Smeaton Bay would be likely to sight a commercial vessel serving Quartz Hill during their visit, and all boaters spending time in the area would notice project-related airplane traffic. Due to the current existence of similar activity, and user's relatively low sensitivity, the effects of this traffic would be insignificant. Higher traffic levels could probably be expected during the construction phase, in which case these impacts would be moderately significant.

A second and more important direct effect concerns project noise audible in the wilderness area to the northwest of the project area. Aircraft noise and nonaircraft mechanical noise associated with the bulk sampling activities was reported at Winstanley, Punchbowl, Big Goat, and Wilson lakes (Johnson et al. 1983; Barber 1983c); due to its location within this group, project noise probably was also audible at Upper Checats Lake. This area is within the use concentration area of the Monument, and is the most popular inland recreation area in the Monument. The five cabins in this area can be expected to attract an average of about 2,475 RVDs (345 visitors) per year (Forest Service 1983a). Additional estimates for specific nearby features in 1983 include a combined total of 290 RVDs and 430 visits at the Winstanley Lake trail shelter, the Winstanley Creek trail, and the Punchbowl Lake trail (Forest Service 1983b). At a minimum, then, this area can be expected to receive about 2,765 RVDs and 775 visits in a given year, plus an unknown amount of fly-in use not associated with cabins.

The sensitivity level of these users to noise and visual intrusion is high relative to Monument users in general, because of expectations for a high quality wilderness experience interrupted only by occasional aircraft noise. Noise impacts on recreationists depend upon the context of the recreation experience and the connotation or message associated with noises by recreationists (Dailey and Redman 1975, p. 7; Harrison et al. 1980, p. 5). Even faint noises would be perceived by recreationists as inappropriate to the setting if those noises have a meaning that makes them intrusive. In the Misty Fiords wilderness context, where motorized transport is necessary and accepted but other mechanical noise does not occur, mechanical or blasting noise would produce a negative and annoyed reaction due to its message that an activity in conflict with wilderness is occurring nearby. Management policy established for the Monument (Forest Service 1982a, pp. 3-41 to 3-43, 1982c) and general Forest Service regulations for wilderness management (36 CFR 293) also indicate that aside from the ANILCA exception for motorized transport, the Monument wilderness should be free of mechanical noise.

Based on this potential sensitivity to foreign noises, wilderness recreation values would be diminished by project development in the area from Winstanley Lake to Wilson Lake even though the noise levels fall below the regulatory guidelines. If the sensitivity and response to change were as indicated by the previous APS data, the project could be expected to adversely affect at least 540 annual visitors and about 1,935 RVDs of use, of which roughly 310 visits and 990 RVDs would be displaced. In reality, behavior would probably differ from this pattern in two ways. The percentage of adversely affected recreationists would probably be higher than 70 percent, because southeast Alaska wilderness users are more sensitive than respondents in general to the postulated APS site changes. Secondly, users of the Winstanley-Wilson Lake area might be less inclined to stop going there because few other lakes in or near the Monument appear to have similarly striking site attributes, even though lake recreation substitutes in general are abundant. Consequently, most recreationists would probably continue to use the area, but the value of their recreation experience would be significantly reduced.

Overall, the effect of project area noise on wilderness use must be considered a moderately significant impact. The affected number of visitors and amount of use would be substantial, and the magnitude of the impact would be amplified by user sensitivity to noise and visual intrusion. Impact significance in this case is moderated somewhat by the fact that noise within the wilderness area might not be a regular, continuous, or uniform occurrence (see Section 4.1.8).

An additional source of impacts would be light from project facilities, which might reflect off cloud cover and be noticeable within the wilderness area (Barber 1983c). The likelihood and potential frequency of this phenomenon are currently unknown, but observance of light reflection could be expected to have a very adverse effect on overnight wilderness users.

Recreational use of the Monument would increase substantially with project development, primarily as a result of project-induced growth in the Ketchikan area. Projections indicating the range of potential increased local use attributable to the project are presented in Table 4-40. These projections are based upon Ketchikan recreation participation rates specific to the Monument (Entercom Inc. 1982b, p. 171), as applied to projections of Ketchikan-area population changes resulting from the project.

The projections indicate that by project year 17 growth in the Ketchikan area attributable to Quartz Hill would generate from 5,400 to 14,900 additional RVDs within the Monument. The high projections may represent the most likely outcome, because this is the only estimate that accounts for increasing participation over time and allows multiple trips to the Monument by some recreationists in the same year. Recreation participation by southeast Alaska residents has increased sharply in recent years (Alves 1980, p. IV-10), while APS responses indicate that some local recreationists do make more than one trip per year to the Monument (Clark 1981, Table 21a). This projection also incorporates a geographic shift in use toward Misty Fiords, as programmed development activities lead to future reductions in primitive recreation opportunities elsewhere in the Ketchikan area.

The population of the Quartz Hill camps would also generate substantial recreational use, although the degree to which this use would occur away from the project area is unknown. Peak recreation activity during the construction period would range from an estimated 7,600 RVDs to 16,200 RVDs. These levels of activity are considerably higher than the corresponding year 2 projections of increased use from Ketchikan, but the distribution of this use, and therefore the effect on the Monument, would depend upon the availability of transportation at the camps. Recreational use by camp residents during the operations period would be much lower, in the range of 1,000 to 3,800 annual RVDs by year 7, due to the rotation and shift scheduling to be employed.

A second set of projections representing baseline (without project) conditions is included in Table 4-41, incorporating potential changes in nonlocal, local, and business-related recreational use. The key variables in this case are the rate of growth of nonlocal traffic through Ketchikan, participation rates over time, and changes in business-related use associated with phase changes in the Quartz Hill project. The low projections incorporate 1 percent annual growth in nonlocal use combined with local use increases at the rate of population growth. The high estimates represent 5 percent annual nonlocal growth plus an 18 percent cumulative increase in local participation rates by year 17 and a shift in use toward Misty Fiords. Business-related recreation use has been adjusted downward from 8,900 RVDs in 1983, to reflect the closure of the Quartz Hill camp and an expected postconstruction decline in personnel conducting field work related to Quartz Hill.

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TABLE 4-40

PROJECTED PROJECT-INDUCED RECREATIONAL USE INCREASE
IN THE MONUMENT (IN RVDs)

Projection	Year 2	Year 7	Year 12	Year 17
Low	4,267	5,313	5,313	5,421
Medium	5,936	7,426	7,426	7,574
High	10,211	13,211	13,872	14,856

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TABLE 4-41

BASELINE RECREATIONAL USE INCREASES IN MISTY FIORDS
(In RVDs)

Projection	Base Year	Year 2	Year 7	Year 12	Year 17
Low	41,560	40,200	42,500	44,900	46,600
Medium	41,560	45,300	50,200	55,800	60,800
High	41,560	49,200	58,000	64,400	79,500

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As indicated by a comparison of the two sets of projections, project development would drive use of the Monument to a minimum of 11 percent above the without-project condition by year 2 and 13 percent above trend by year 7. Middle level projections indicate above-trend increases of 15 percent by year 9, while comparison of respective high projections shows an increase of 23 percent by year 9.

Relative aggregate use increases of this magnitude represent significant indirect effects of project development, particularly when the greater probability of the larger increases and the nature of this use are considered. The year 7 high projection for project-induced local use (13,200 RVDs) is equivalent to about 39 percent of the base year activity level for this type of use (excluding business-related recreational use and cruise ship, tour boat, and flightseeing use).

The effects of sharply increased use of the Monument are unclear because its social and physical carrying capacities have not been established. Recreation research has demonstrated that wilderness users have a preference for little contact with other users, although more contact than is preferred does not necessarily diminish the experience and increasing use of a given area does not automatically decrease recreation quality (Hendee et al. 1978, pp. 176-177). There definitely appears to be a tradeoff between quantity and quality, however, such that increasing use beyond some point would produce congestion sufficient to reduce per visitor benefits so much that total benefits would decline (Shecter and Lucas 1978, pp. 4-6; Cicchetti and Smith 1976, pp. 3, 78-88).

The local user population appears to reflect these preferences for little contact. Two-thirds (67 percent) of all Ketchikan respondents to the Alaska Public Survey reported that their favorite overnight recreation site would be less attractive if they encountered more recreationists, and 35 percent reported they would stop using their favorite site under such conditions (Clark and Johnson 1981, p. 109). Among southeast Alaska residents who reported use of certain wilderness areas, including the Monument, 73 percent reported their site would be less attractive and 33 percent would stop using it (Clark 1981, Table 33a). In the statistically insignificant sample of Misty Fiords users, the adverse response was 100 percent (Clark 1981, Table 33a). These figures are supported by the Entercom survey results, where 90 percent responded that wilderness recreation was important and 73 percent of those respondents felt that solitude was important to the wilderness experience (Entercom Inc. 1982b, pp. 102-103). This high sensitivity would only apply to the primarily local component of the Monument use, however, as other survey results indicate that few cruise ship visitors to the region are sensitive to the presence of other vessels, people, and aircraft (Koth 1980, pp. 48, 51, 53-54).

Increased use of the Monument would therefore have a high probability of adversely affecting many current users. The number of additional recreationists required to produce an adverse response cannot be estimated, but an increase on the order of 30 to 40 percent would be expected to produce decreased satisfaction and probably some

displacement. The high projections from Table 4-40 suggest that the project could generate an increase that large in the primarily local use component. If these users react according to the APS responses, roughly 7,000 current annual visits and 16,500 RVDs of use would be adversely affected and up to 3,500 visits and 8,300 RVDs would be displaced. While numerous alternative sites could be used by persons displaced from the Monument, these sites could not be regarded as perfect substitutes due to the physical attributes of the Monument. Further, it is possible that alternative sites for Misty Fiords users would also be affected by the increased level of use.

The effects of this use would be greatest on the most popular and sensitive activities or resources. The density of boats in the Rudyerd Bay area would probably be roughly double the current level by 1995. Although the area currently does not appear to be crowded and the resulting boat density would still be low relative to many locations outside the Monument, boaters preferring solitude would likely choose to avoid overnight stays in the Rudyerd Bay area. Cabin utilization in Misty Fiords would be increased by an estimated 30 percent in year 2 and 37 percent by year 7, exclusive of any without-project growth. Project-induced growth would likely strain the practical capacity of the Wilson Lake cabins by year 2, and would push use of several other cabins close to this condition by year 7.

The significance of these indirect effects depends upon the evaluation of impact magnitude. To local users, the effects would be very significant due to the degree of increase in use and the large number of users adversely affected by this increase. From a management perspective, however, this increase in use would probably have only a moderate effect on opportunities for a high quality wilderness experience because current overall use levels are low. A moderate impact magnitude rating produces an overall rating of moderately significant impacts to Monument recreation values. This conclusion is conditional upon the assumption that current use density is well below social carrying capacity, an assumption that is consistent with the judgment of the Monument staff (Barber 1984a). If use density in the central area of the Monument is actually at or near reasonable capacity, however, impacts would be very significant.

The proposed project would also cause increased recreational use in the Ketchikan area outside of Misty Fiords, because Ketchikan residents spend much of their recreational time on or near Revillagigedo and Prince of Wales islands. Using general recreation participation characteristics from the Entercom (1982b, pp. 168-170, 671-718) survey, project-induced use in the Ketchikan area was estimated at from 39,300 to 61,400 RVDs in year 2 and 49,300 to 79,600 RVDs by year 7. These figures are from 14 percent to 28 percent higher than reported base year use (exclusive of ferry and cruise ship use) of 286,600 RVDs, and represent growth of 15 to 19 percent above without-project conditions by year 7. Use increases of this magnitude, which include the project-induced use directed toward Misty Fiords, would not cause severe recreational crowding in the Ketchikan area. This growth and

the assumed baseline growth for year 7 account for more than 50 percent of total current use, however, so the combined effect would probably produce crowding and/or lack of availability at the more popular facilities and locations.

Townsite or Phase-In Housing Option

Direct effects on recreation in the immediate project area would be increased somewhat by development of a townsite within the project area. The most significant difference would occur if the Bakewell townsite were developed, as this would alter recreation in an area that would not be heavily affected by the proposed project. Construction of a town of nearly 2,000 persons at Bakewell would adversely affect use of Bakewell Arm, the Bakewell Lake trail and cabin, and Bakewell Lake itself. Use of these sites and areas is currently about 600 to 700 RVDs per year. Activity levels at the Bakewell town would probably be so high that virtually all of this current use would be displaced.

Townsite contribution to project noise and light reflection would probably not have a large additive effect on users of the adjacent Winstanley-Wilson Lake area, if air traffic followed saltwater routes away from these recreation sites. A full service community of 2,000 residents would generate a large volume of air and water traffic, and this would have a significant effect on recreationists using Smeaton Bay and lower Behm Canal. Most current users of Smeaton Bay would probably abandon it for quieter areas. Recreationists would continue to use lower Behm Canal because it is the shortest and most direct approach to the Rudyerd Bay-Walker Cove area, but time spent in areas such as Alava Bay would probably diminish. The impact of traffic on existing use in this portion of the Monument would be moderately significant.

A community near Quartz Hill would also generate a large volume of outdoor recreational activity that would be distributed according to the residents' willingness to travel and available transportation. Given the popularity of coastal activities and location factors, most of this use would clearly occur within the Monument. Based on applicable participation rates (Entercom 1982b, pp. 168-170, 671-718), in year 2 the townsite population would generate from 18,900 to 32,100 RVDs of use among the recreational activities typically occurring within the Monument. The range of projections for year 17 is from 27,600 to 51,100 RVDs. The Monument would probably receive virtually all of this use employing boat transportation, except for long cruising vacations, and most of the use requiring air transport. Travel time willingness for weekend recreation is two to three hours for most users (Clark and Johnson 1981, p. 153), and few potential recreation destinations outside of the Monument would be within such a range. Within the Monument, Rudyerd Bay and Walker Cove would be within about two hours of a town at Bakewell or Wilson Arm and about four hours from the Keta townsite. Local geography would restrict, somewhat, the distribution of use from a Keta townsite.

The increase in use of the Monument by Ketchikan area residents under the townsite option has been projected at from 1,600 to 3,800 RVDs per year in year 2 and 1,500 to 4,200 RVDs by year 17. An intermediate estimate for total increased use attributable to the project in year 2 would be in the general vicinity of 29,000 RVDs. This figure is equivalent to 70 percent of total current use from all sources, including business- associated use and cruise ship, tour boat, and flightseeing use. An additional 29,000 RVDs would exceed the roughly 28,000 RVDs projected for the local use component in year 2 without the project. Consequently, direct or active surface use of the Monument would more than double over a five-year period if the townsite option were implemented.

As with the indirect effects of the proposed action, the likelihood and extent of congestion costs and reduced total benefits resulting from a use increase of this magnitude can only be hypothesized. It is certain that many current users would be adversely affected, and opportunities for solitude and a high quality wilderness experience would be significantly reduced. Rudyerd Bay would be within day-use range of a town at Bakewell, for example, which would alter the character of use of the most popular destination in the Monument. In short, development of a townsite would have major, long-term effects throughout most of the Monument, and would result in very significant overall impacts to Monument use and values.

4.3.7 Aesthetics

The significance of the visual impacts that may occur from the project is based on a number of viewing criteria: the viewer's concern for the visual environment, the frequency and duration of viewing activity, and the visibility of project features from sensitive viewing areas. The degree to which project-induced landscape alterations conform to the Forest Service visual quality management objectives is an additional consideration. Noise impacts of the project, which have an aesthetic component, have been addressed as a separate issue (Section 4.1.8).

4.3.7.1 No Action

If the project were not built, the visual quality would exhibit similar characteristics to the presently existing Monument.

4.3.7.2 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Commute Option

The visual impacts of the proposed project have been evaluated by examining the potential impacts of each of the major project components: mine development, Tunnel Creek processing facilities, Wilson Arm wharf, and Boca de Quadra tailings disposal. Based on an assessment of the potential impacts of each of these components, an overall impact rating of moderately significant has been determined.

Mine Development

The Quartz Hill mine site is semienclosed by a number of prominent ridges, which form a horseshoe ring around Quartz Hill. Because the mine site's inland location is shielded by mountain ridges, the mine pit area, waste rock disposal areas, sedimentation ponds, access roads, and crusher would not be visible from boats on Wilson Arm. Views experienced from the mine site location are severely restricted, enclosed by the steeply sloped ridges descending to a central valley, Bear Meadow, which contains White Creek and Beaver Creek. Views of these landscapes are likely to be limited to mine workers or persons viewing from aircraft, providing the weather permits flying at altitudes higher than the ridge elevations around the mine site. The potential increase in demand for flightseeing is addressed in Section 4.3.6, Recreation. As the pit enlarges, some aircraft chartered for flightseeing may purposefully take a path that gives a view of the mine.

The visual impacts created from mining and processing the ore would increase over the life of the mine due to the widening and deepening of the mine pit. The total area of visual impact for the mine pit area, including the pit location, waste rock disposal areas in the Hill Creek and Beaver Creek drainages, water quality control facilities, roadway development, and mine services area, is approximately 21 sq mi (13,500 ac) (Bechtel Civil and Minerals 1983b). The longest linear distance across the pit would extend 2.0 mi. The mine would be nearly 1,900 ft deep at its deepest point. The area of visual impact, locations from which unobstructed views of the landscapes include all or part of the project features, extends from the surrounding ridge tops inward, encompassing Bear Meadow, Quartz Hill, the entire Beaver Creek, White Creek, and Hill Creek drainages, and segments of the Blossom River drainage.

The location of the mine site has been assigned maximum modification visual quality management objectives by the Forest Service. The lowest possible sensitivity level, Level 3, has been assigned to the mine site area, reflecting the low viewing frequency of these landscapes.

Viewing of the Quartz Hill mine site area from background distance zones, distances of 5 mi or greater, would occur only from aircraft. The level of landscape modification acceptable for this category requires that alterations conform to the natural landscape when viewed from background distance zones. To the extent that the mine site would be visible from aircraft, the proposed mining development does not comply within the guidelines for maximum modification visual quality management objectives. Very significant visual impacts would be experienced by viewers in aircraft if they were expecting a wilderness experience. Persons flying over the mine site would have different expectations and, therefore, adverse visual impacts would not result for them. However, the potential significance would be somewhat reduced due to the infrequent viewing activity that is anticipated for this area at the present time.

At the termination of mining activity all project structures (i.e., crusher facilities and building structures associated with the mine services area) would be removed. The seeding, planting, regrading, and contouring of access roads and rock disposal areas proposed by U.S. Borax would be necessary to restore the area so that the landscape alterations in this area blend to the greatest extent possible with the natural landscapes. Figure 4-21 presents a computer-generated representation of the existing topography in the vicinity of the pit and the same view after the pit has been abandoned and has filled with water, making it a permanent lake. Figure 4-22 shows the Hill Creek valley as it currently exists and as it would look after the waste rock disposal areas are completed.

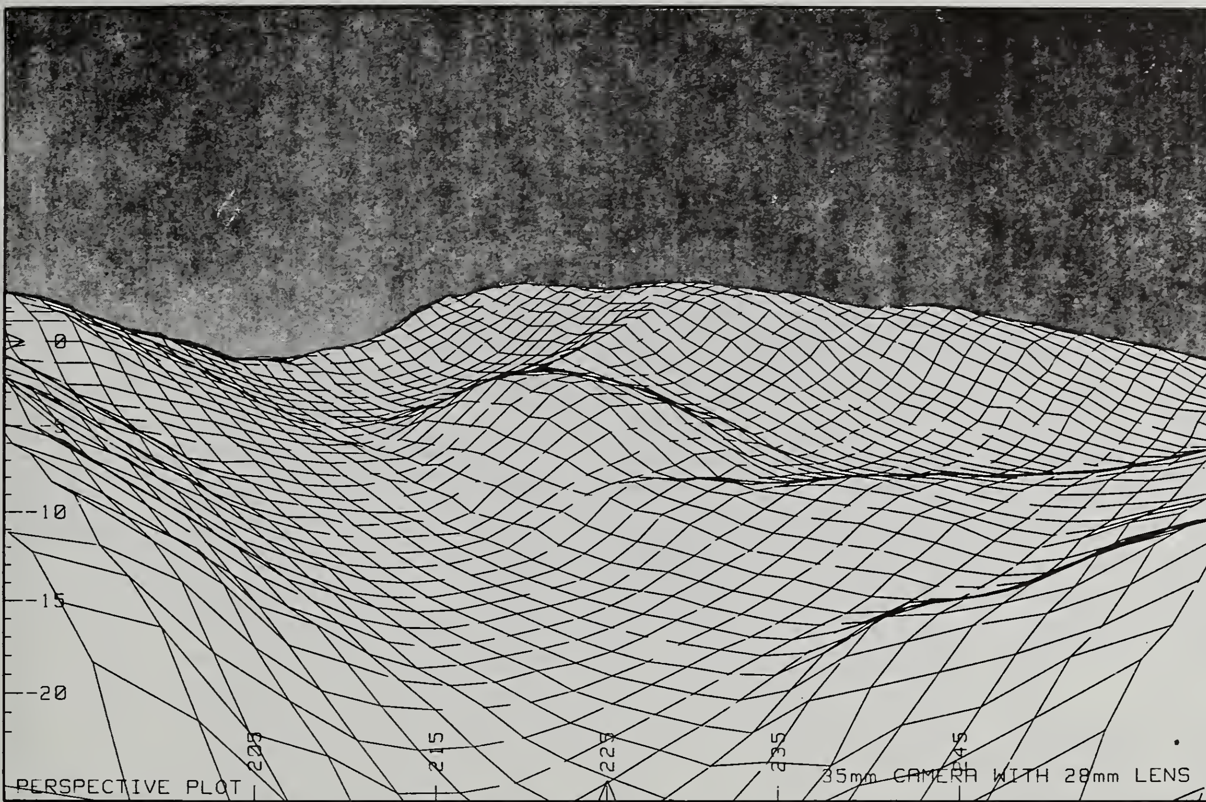
Tunnel Creek Processing Facilities

A 210-ac area would be directly impacted during the development of the processing facility site and housing facilities at Tunnel Creek. This disturbance would be caused by the removal of timber, cut and fill construction, and extensive grading required to prepare the site for the processing facilities. The proposed site location is within middleground distance zones of Wilson Arm and is characterized by a dense coniferous forest consisting primarily of Sitka spruce and western hemlock species.

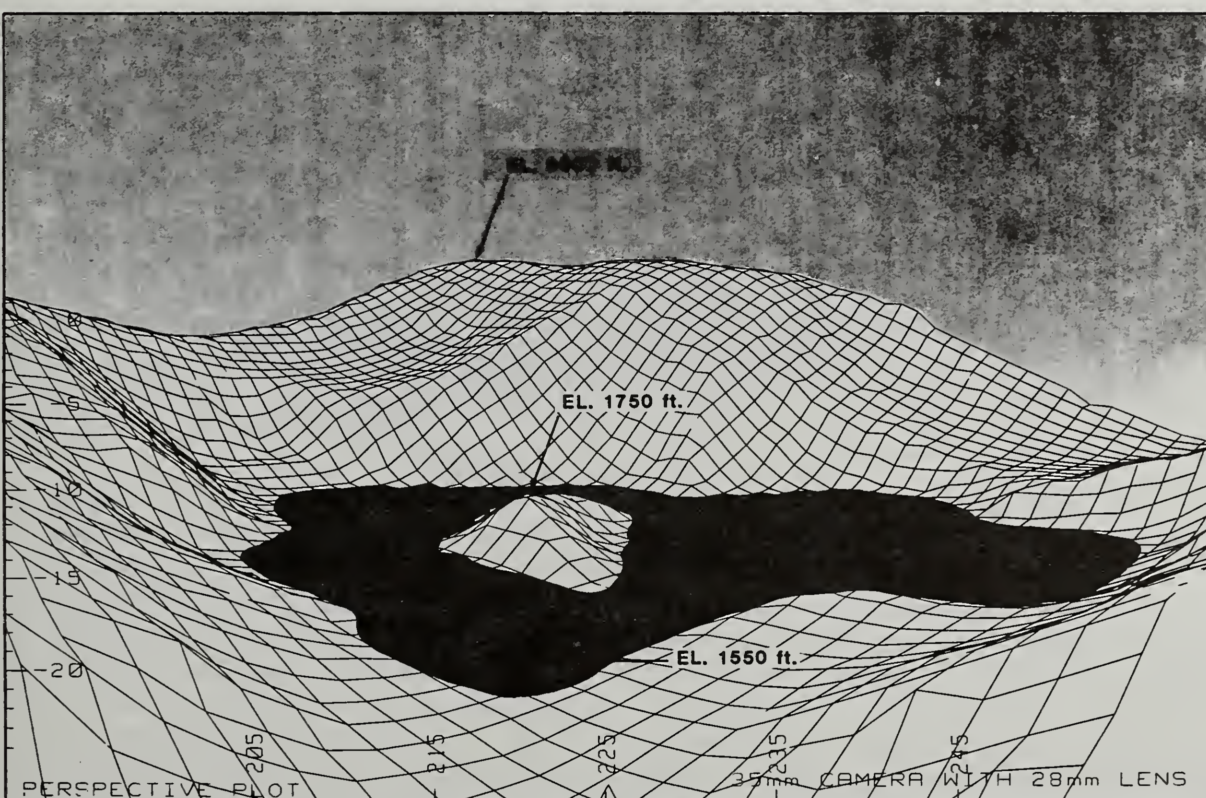
Landscapes in the Tunnel Creek drainage are described as some of the more scenic landscapes in the nonwilderness area (Forest Service 1982a). This area has been assigned partial retention visual quality management objectives. Landscapes with retention classifications are concentrated along the entire shoreline of Wilson Arm. High sensitivity ratings, Level I, reflect the high viewing potential of these landscapes from Wilson Arm, the primary air and water travel routes through the nonwilderness area. The degree of landscape alterations that are acceptable in the Tunnel Creek area are restricted to activity that remains visually subordinate to the characteristic landscapes at the processing facility site location, and further restricted to activities that are not visually evident along the shoreline landscapes.

The introduction of linear roadways and man-made buildings, storage tanks, and power plant structures emitting plumes nearly 520 ft high in the Tunnel Creek area represents a visual impact to the viewer situated on Wilson Arm.

An analysis of the unobstructed viewing potential toward Wilson Arm from two viewpoint locations at the Tunnel Creek processing facilities site was conducted. It was assumed that the viewing range along an unobstructed line-of-sight toward Wilson Arm from these viewpoints would be reciprocal from locations on Wilson Arm looking towards Tunnel Creek. The first viewpoint selected represents the highest elevation at the site where clearing is likely to occur, at the 900 ft elevation level. The second viewpoint represents the elevation that is equivalent to the height of the midpoint of the tallest facility structure near the center of the proposed site location, the power plant stack. This viewpoint is at the 595 ft elevation level.

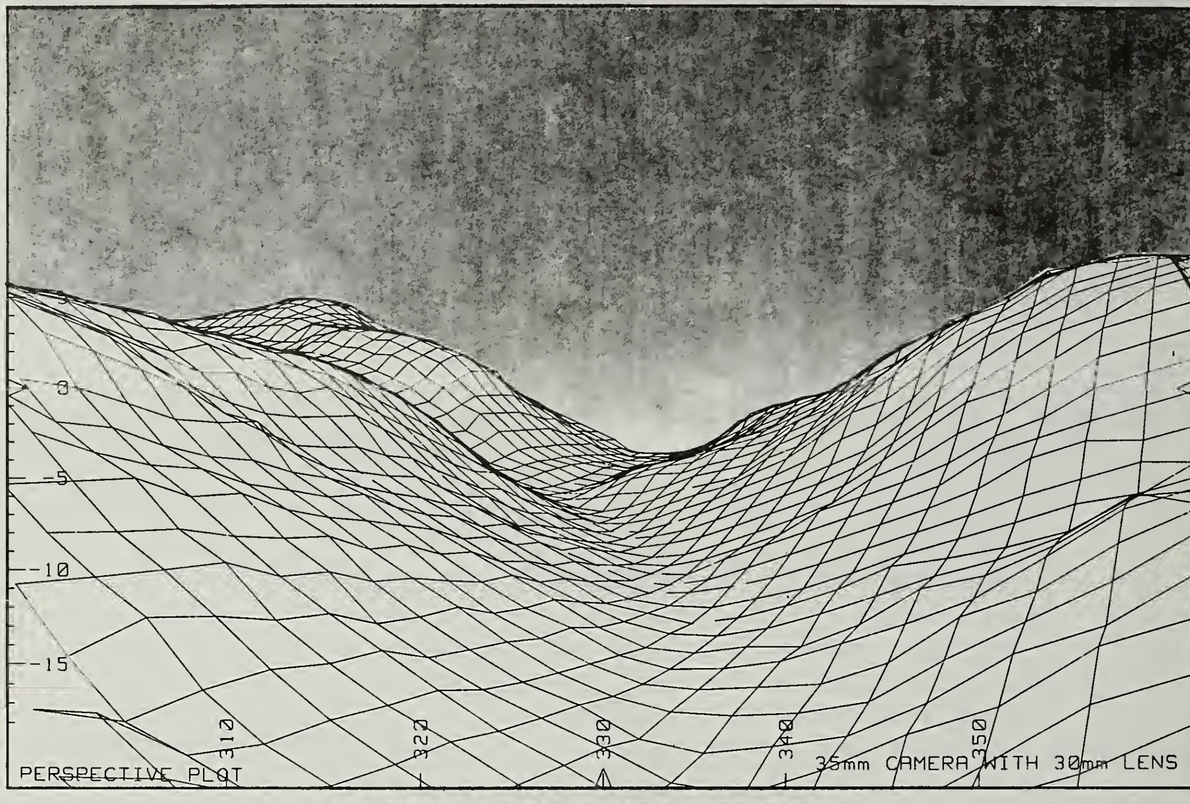


PIT AREA - EXISTING TOPOGRAPHY

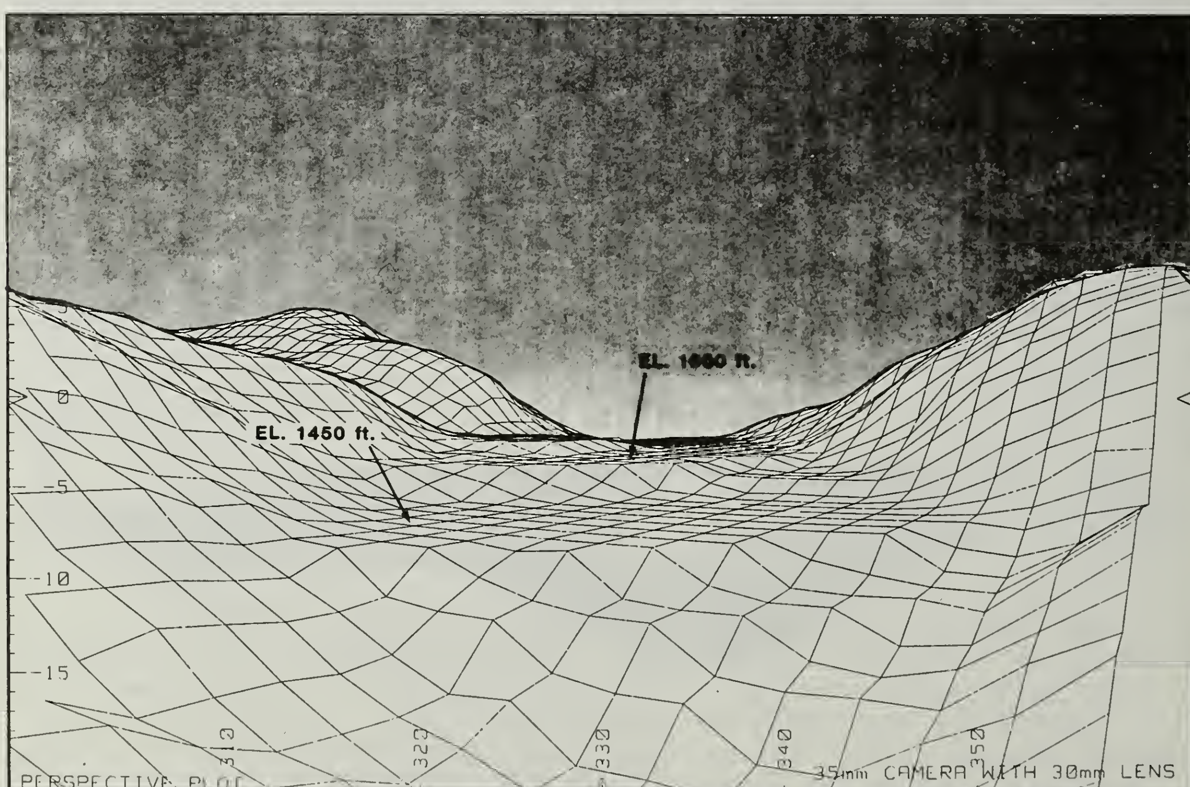


PIT AREA AFTER MINING - WITH LAKE IN PIT

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE **4-21** envirosphere company A Division of EBASCO SERVICES INCORPORATED
VIEWS OF PIT AREA FROM HILL CREEK / WHITE CREEK	
SOURCE FOREST SERVICE DATE APR 84	



HILL CREEK VALLEY - EXISTING TOPOGRAPHY



HILL CREEK VALLEY AFTER COMPLETION OF WASTE ROCK DISPOSAL AREAS

U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE QUARTZ HILL MOLYBDENUM PROJECT MINE DEVELOPMENT EIS	FIGURE **4-22**
VIEWS OF HILL CREEK VALLEY FROM LOWER HILL CREEK	envirosphere company A Division of EBASCO SERVICES INCORPORATED
SOURCE FOREST SERVICE DATE APR 84	

Figure 4-23a represents the viewshed of Tunnel Creek when viewed approximately 800 ft from the east shoreline of Wilson Arm and just south of the mouth of Tunnel Creek. Figure 4-23b represents the viewshed of Tunnel Creek when viewed near the mouth of Tunnel Creek on Wilson Arm. The general locations of these viewpoints are represented, respectively, by viewpoints A and B as shown in Figure 4-23c. These photographs were taken at high tide.

A detailed discussion of the Tunnel Creek viewshed analysis is contained in Appendix M; the conclusions of the analysis are as follows:

- Views toward Tunnel Creek from a boat location corresponding to viewpoint A would not include the power plant stack, but would include any project feature or clearing activity at the 890 ft elevation level or higher. However, the power plant, located at the 500 ft elevation level and any structures at higher ground elevations would be visible from aircraft flying at altitudes of 275 ft or higher directly above viewpoint A. The power plant stack and project structures located at higher elevations could be viewed from boats located near the west shoreline of Wilson Arm and traveling in a direct line-of-sight with viewpoint A (Figure 4-23a). Viewing from this distance would remain within middleground distance zones.

- From viewpoint B (Figure 4-23b), much of the processing facilities site would be visible. The entire site would be visible from aircraft flying at 400 ft altitudes directly over viewpoint B. While continuing north from viewpoint B, views experienced from locations near the east shoreline of Wilson Arm and directed toward Tunnel Creek are soon obstructed by the natural configuration of the north slope nearest the mouth of Tunnel Creek. This applies to travel both by boat and aircraft.

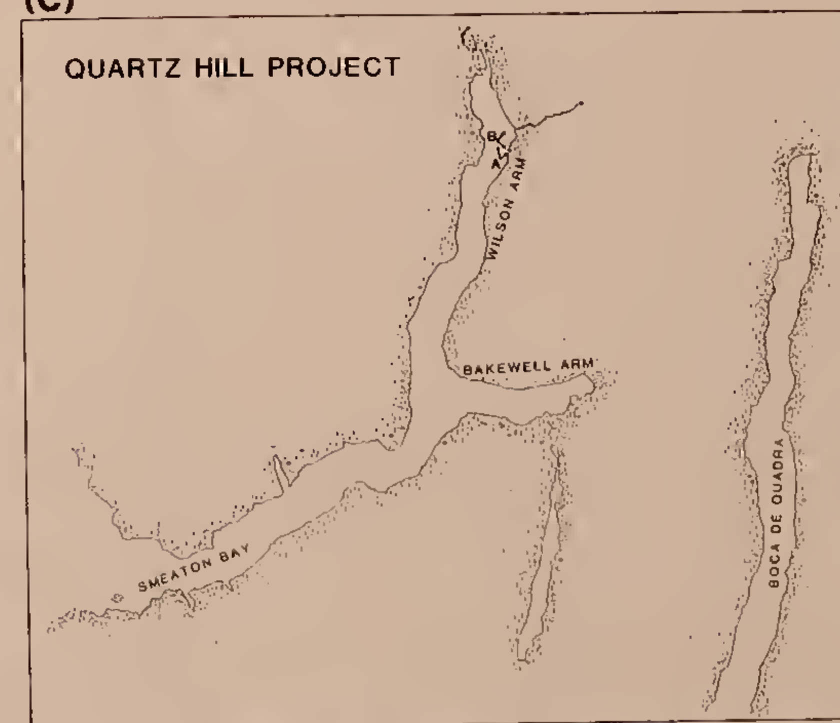
The visual impacts created by the construction of the Tunnel Creek processing facility would be moderated by the visually restricting landscapes features of the Tunnel Creek valley walls. A moderately significant impact rating has been determined for the Tunnel Creek processing facilities.

Stack emissions and fugitive dust emissions could potentially be visible from the wilderness areas. The combined effect of the plume dispersion characteristics, primarily along Wilson Arm and, on occasion, north toward Wilson Lake, and the influences of the mountainous terrain in obscuring long-range views of the landscapes led to the conclusion that from most of the area along the nonwilderness boundary, visual impacts would be negligible. One exception to this determination is at the wilderness boundary on Smeaton Bay. The combination of stack emissions at Tunnel Creek and emissions from the mine site would contribute to visibility impairment in Smeaton Bay. The long line-of-sight viewing range from the south end of Wilson Arm

(A) VIEW APPROACHING TUNNEL CREEK AREA FROM WILSON ARM

(B) TUNNEL CREEK DRAINAGE FROM WILSON ARM

(C)



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
QUARTZ HILL MOLYBDENUM PROJECT
MINE DEVELOPMENT EIS

VIEWS OF TUNNEL CREEK AREA

SOURCE U.S. FOREST SERVICE DATE 1982

FIGURE
4-23

envirosphere company
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is a contributing factor to this potential impact. Although emissions would be visible from locations within Wilson Arm and Smeaton Bay, the concentrations are expected to be less than those allowable for Class 1 areas.

Emissions from trucks and construction-related equipment are a contributing factor to the potential visibility impairment resulting from project activities. It has been determined, however, that visibility impairment from equipment sources is likely to be negligible due to the large particle size of the emissions and the subsequent quick settling characteristics of the particulates. For a more specific analysis of air quality impacts, refer to Section 4.1.1, Meteorology, Climatology, and Air Quality.

Wilson Arm Wharf

The area in Wilson Arm where the wharf facilities are proposed has been assigned a visual quality management objective of retention. The wharf development activities would clearly dominate the natural landscapes from viewpoints from both the air and water surface as close as the midlength of the Wilson Arm fjord. The configuration of the upper end of Wilson Arm lends itself to unobstructed views of project features, particularly from the main air route along the center of the fjord.

The visual impacts of the wharf facilities on potential viewers include indirect effects beyond the physical presence of structures constructed at the wharf site. There would be increased boat and aircraft traffic transporting commuters from the Ketchikan area and barge activity transporting both fuel to the wharf site and processed ore to Grays Harbor, Washington. The result would be very significant visual impacts to viewers boating or fishing in this area of the fjord. Viewers from aircraft enroute to the Forest Service cabin at Wilson Lake, or continuing on to the Big Goat Lake and Rudyerd Bay areas, would experience the cumulative visual impacts associated with both the Tunnel Creek processing plant and access road, and the expanded Wilson wharf and floating construction camp.

Tailings Disposal in Boca de Quadra

The major visual impact of tailings disposal would be the disruption of approximately 22 ac of natural landscape at the proposed Boca de Quadra portal area. Clearing and removal of timber, surface grading, and cut and fill construction to moderate the steeply sloped landscape in the portal area would be required to accommodate the above facilities.

Landscapes bordering the shorelines surrounding Boca de Quadra and all major watercourses within the nonwilderness area are designated as retention areas according to the visual quality management (VQM) objectives. The intrusion of man-made features such as roads, pipeline, docks, and construction equipment does not conform to retention VQM objectives as described in Section 3.3.4. The resulting landscape alteration would not incorporate repetition of the landscape's natural form, line, color, or texture as suggested by retention guidelines of the visual resource management system.

The portal location on the west shore of Boca de Quadra is within 2 mi of the wilderness boundary to the south. Landscapes immediately south of this boundary are assigned preservation VQM objectives. An analysis of the total area of visual impact from which an unobstructed line-of-sight to all or a given project feature is possible was conducted for the Boca de Quadra tailings disposal component (Bechtel Civil and Minerals, Inc. 1983b). According to this analysis, the proposed tunnel portal location would be visible from wilderness landscapes along the east shoreline just south of the boundary as well as from viewpoints on the water from the center of Boca de Quadra east to the shoreline.

The extent of clearing, grading, cut and fill, and construction activity would determine the level of visual impact to viewers from preservation landscapes. Retention of the natural timber along the south border of the tunnel portal development area, in order to screen, to some extent, the construction activity, would help minimize visual impacts from the wilderness area.

Landscape modifications would, therefore, be considered moderately significant visual impacts. The low viewing frequency would moderate the significance to some degree; however, the viewing potential of project-related structures from preservation or wilderness landscapes warrants the moderately significant impact rating.

4.3.7.3 Tunnel Creek Mill with Boca de Quadra Tailings Disposal and Townsite

The impacts of this alternative would be the same as those discussed in Section 4.3.7.2 with the following exceptions.

The impacts of a townsite on the visual quality of the project area would have cumulative effects that would be greater than those of the proposed project. An overall impact rating of very significant has been determined for this alternative. The townsite would provide a destination point, possibly as a refueling location, and could attract recreationists and visitors. The alteration of the landscape caused by the townsite construction and the increased number of viewers, including workers and their families, are the primary factors that would contribute to the impacts. The compactness of the town, architecture of the buildings, and visual uniformity of the development would influence the impact rating. Assuming that the selected building designs were generally compatible with the natural landscape, the townsite would have a moderately significant visual impact.

The visual impacts are expected to be greater for the Wilson I and Wilson IIa options than for the Bakewell townsite for the following reasons:

- o Cumulative impacts would result from development of the townsite, Tunnel Creek mill, and the wharf facilities on Wilson Arm.

- o There is a longer viewing distance associated with the Wilson townsites, whereas the Bakewell site would be less visible to people traveling by boat along Wilson Arm.

One advantage of either of the Wilson townsites is that the impacts would be concentrated in the upper reaches of Wilson Arm. Development of the Bakewell townsite would result in a dispersion of impacts. This townsite would dominate the Bakewell Arm landscapes.

Discharge of the mill tailings in the middle basin of Boca de Quadra is proposed as an alternative. The proposed optional discharge point is located just offshore of the wilderness area on the west shoreline of Boca de Quadra, approximately 3 mi south of the wilderness/nonwilderness boundary.

Transport of the tailings would occur either by way of a tunnel leading directly from the Tunnel Creek mill site to the alternative discharge point, or by way of a submarine pipeline extension from the previously proposed discharge point within the project boundary to the alternative location outside the boundary.

Significant long-term visual impacts would result from the construction of a direct mill-to-discharge point tunnel, due to the land disturbance required to construct the tunnel portal area. This alternative would result in land disturbance and the introduction of man-made structures in an area located in or offshore of Misty Fiords National Monument. Monument landscapes have been assigned preservation visual quality management objectives by the Forest Service. Among preservation landscapes, landscape alterations are prohibited with the exception of developing very low visual impact recreation facilities. This option proposes land management activities that are unacceptable in the wilderness landscapes. With a submerged pipeline, no additional impacts would occur.

4.3.7.4 Tunnel Creek Mill with Wilson Arm Tailings Disposal

The impacts of this alternative are essentially the same as those described in Section 4.3.7.3. Locating the pipeline adjacent to the access road would result in insignificant incremental impacts. At the discharge point, the discharge structure mixing chamber would project above water level.

One advantage of this tailings disposal option compared to the other tailings disposal alternatives is that the visual impacts would be consolidated rather than dispersed. In addition, the tailings pipeline and outfall would not be visible from the wilderness landscapes, which have been assigned preservation objectives. With the townsite suboption, this alternative would have moderately significant visual impacts. Less significant impacts would occur with the commute suboption.

4.3.7.5 Beaver Creek Mill with Boca de Quadra Tailings Disposal

The Beaver Creek mill site is visually shielded by mountain ridges, similar to the mine site. Since this site would not be visible from Wilson Arm, the impacts would be insignificant.

The impacts of the tailings disposal component are discussed in Section 4.3.7.2 and the impacts of the townsites are addressed in Section 4.3.7.3. The overall impacts of this alternative with the townsite suboption would be moderately significant, as the Boca de Quadra tailings disposal alternative would have significant impacts, as would the townsite. With the commute suboption, the visual impacts would be reduced.

4.3.7.6 Beaver Creek Mill with Wilson Arm Tailings Disposal

This alternative would result in insignificant impacts if the commute option were exercised. This determination was made because the Beaver Creek mill site would not be visible from Wilson Arm and the tailings pipeline would be compatible development with the access road. The presence of a townsite would cause an overall impact of moderate significance.

4.3.7.7 Beaver Creek Mill with On-Land Tailings Disposal

Both Tunnel Creek and Aronitz Creek have been assigned retention VQM objectives near the mouth of the creek. Partial retention VQM objectives were assigned to the upper reach of Tunnel Creek. Whereas, maximum modification VQM objectives were assigned to the upper reach of Aronitz Creek (Forest Service 1981c). The degree of landscape alterations acceptable according to the objectives is not compatible with this alternative. The tailings, which would raise the valley floor approximately 800 to 1,000 ft, would introduce a massive, uniform, gray face to the valleys. The dam at Tunnel Creek would visually dominate Wilson Arm and would radically alter the existing landscape. Tailings in Aronitz Creek would be somewhat obscured by the high mountain ridges. The on-land tailings disposal would cause a very significant visual impact.

The location of the mill at Beaver Creek would not moderate these impacts. The visual impacts would be exacerbated by the development of a townsite. The overall impact of this alternative with the townsite suboption would be very significant due primarily to the on-land tailings disposal component.

4.3.7.8 North Meadow Mill with Boca de Quadra Tailings Disposal

The North Meadow mill site would not be visible from Wilson Arm or Boca de Quadra where the viewers are concentrated. This component would result in insignificant impacts. The impacts of tailings disposal in Boca de Quadra are addressed in Section 4.3.7.3. The viewing of the Keta townsite would be infrequent because of the low usage of Boca de

Quadra. It is unlikely that the Keta townsite would be viewed from wilderness landscapes to the south. The visual impact of this component would be insignificant. The overall impact rating for this alternative would be moderately significant with the townsite suboption and less significant with the commute suboption.

4.3.7.9 North Meadow Mill with On-Land Tailings Disposal

The visual consequences of depositing the tailings in the Tunnel Creek and Aronitz Creek valleys are discussed in Section 4.3.7.7. The North Meadow mill site would not be visible from Wilson Arm or Boca de Quadra where viewers are concentrated. This component would, therefore, result in insignificant impacts. The townsite impacts would be the same as previously discussed. This alternative has been designated an overall impact rating of very significant. This is due to the on-land tailings disposal component.

4.3.8 Power Resources

4.3.8.1 No Action

Energy consumption associated with current activities at the mine site would be reduced to a level needed to support whatever activity is undertaken. Since this would not result in an increase to current limited use levels, it would have no effect.

4.3.8.2 Proposed Project

The current plan is to supply No. 2 distillate oil by barge to the facility, although crude oil or heavy (e.g., No. 6) oil also could be used, to generate up to 100 MW of electric power on-site. The quantity of oil required (950,000 bbl/year) is only about 2.5 percent of Alaska's refining capacity. The oil could also be supplied from the lower 48 states. Given the availability of oil to U.S. Borax, its fuel consumption is not expected to significantly impact supplies of oil to other Alaska consumers. Approximately 80 bargeloads of fuel, each with a capacity of 500,000 gallons, would be required annually, or an average of 1 barge every 4 to 5 days. Other impacts of on-site power generation are addressed in preceding sections on the affected resources.

Diesel, aviation, and other fuels would also be required to transport, workers, power equipment, and ship processed ore, and move other materials to and from the site.

4.3.8.3 Other Alternatives

Those alternatives involving townsites would have impacts similar to those of the proposed project with the exception of the townsite effects. The townsites would require additional energy for the residential and commercial needs of the proposed communities. These differential effects would not be significant.

4.4 MITIGATIVE MEASURES

The Council on Environmental Quality has defined mitigation to include the following:

a) Avoiding the impact altogether by not taking a certain action or parts of an action;

b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation;

c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

e) Compensating for the impact by replacing or providing substitute resources or environments.

To the degree possible, the planning process for the proposed Quartz Hill project has emphasized avoiding or minimizing impacts (definitions a and b above) through the careful selection of alternatives and through project modifications that meet these objectives. For example, adopting a supplemental water supply source on the Blossom River will avoid potential impacts from a well field on the Wilson River. Also, the impacts of the Blossom alternative are expected to be minimal compared to other alternatives. Not all potential impacts can be mitigated in this way, however. For example, access to the mine will require expansion of existing roads or construction of entirely new roads. Although specific construction and operation procedures will be used to reduce or eliminate potential impacts (definition d), these roads will impact the area for the life of the mine. At the termination of the mining operation, this impact will be mitigated by rehabilitating or restoring the affected environment (definition c). Where no reasonable mitigation measures can be developed according to definitions a through d, compensation can be used (definition e). For example, spawning channels or salmon egg incubation boxes (discussed in the following sections) can provide a substitute for lost spawning or incubation habitat.

Specific measures that reduce or prevent certain potential impacts have been committed to by U.S. Borax and are now incorporated into the proposed project or alternatives. These measures are not reviewed or repeated in this mitigation section, but are summarized in Table 4-42. The avoidance of certain impacts by selecting the most benign alternative for certain project components was also discussed in Section 2.5.

A multiagency mitigation and monitoring meeting was held in Juneau, Alaska, on October 15-16, 1987. The purpose of this meeting was to clarify and resolve important issues concerning the Quartz Hill development. Major topics discussed included water supply/instream flow requirements, marine habitats, wetlands, oil tanker transfer

TABLE 4-42

SUMMARY OF MAJOR MITIGATION MEASURES INCORPORATED INTO PROJECT PLANNING THAT AVOID OR MINIMIZE POTENTIAL IMPACTS

Project Activity	Potential Impact Issue	Mitigation Measure to Avoid or Minimize Impact
Road Construction	Sediment and erosion runoff to streams affect fish	Adherence to erosion and landslide control measures required by current U.S. Forest Service Special Use Permit for Access Road Construction
		Utilize construction windows to avoid critical periods of fish use
Increased Work Force in Ketchikan Area	Increased use of existing facilities	Increase public facilities such as social services, recreation, port facilities, etc.
	Increased recreation in mine area	Utilize commute option with no townsite at project site (this minimizes free time for recreational activities)
	Increased demand for fishing and hunting	Commute option minimizes this in project area
		Increased pressure can be avoided or minimized through regulation by ADF&G
Air Emissions (e.g., from power generation or woodstoves)	Poor air quality; visual effects	Meet emission standards
Water Supply Dam	Potential dam failure	Meet dam design and operation requirements
	Alteration of instream flows downstream of project	Meet streamflow requirements defined by NMFS and USFWS

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TABLE 4-42 (Continued)

SUMMARY OF MAJOR MITIGATION MEASURES
INCORPORATED INTO PROJECT PLANNING THAT AVOID
OR MINIMIZE POTENTIAL IMPACTS

Project Activity	Potential Impact Issue	Mitigation Measure to Avoid or Minimize Impact
Water Supply Intake	Dewatering of fish habitat in Wilson or Blossom rivers	Avoided through location and design (e.g., avoid Wilson River, remove weir from design; install subsurface infiltration bed in Blossom River)
Project Sediment and Erosion Runoff	Decreased water quality/ potential effects on fish	Utilize water treatment to meet NPDES and ADEC standards (e.g., water treatment facilities and erosion control ponds)
Pipeline Construction and Operation	Sediment and erosion runoff	Implement erosion and sedimentation control plan and measures
	Pipeline failure	Implement maintenance and monitoring measures
	Visual effects	Utilize spill containment structures (e.g., catch basins)
		Place pipeline adjacent to access road to minimize need for second corridor
Blasting	Mortality to aquatic organisms	No underwater blasting or, if needed, avoid critical periods for fish
		Meet requirements for underwater blasting
Power Generation/ Transmission	Potential disturbances to terrestrial and aquatic habitats and wilderness values	Avoided by on-site generation

0735K

TABLE 4-42 (Continued)

SUMMARY OF MAJOR MITIGATION MEASURES
INCORPORATED INTO PROJECT PLANNING THAT AVOID
OR MINIMIZE POTENTIAL IMPACTS

Project Activity	Potential Impact Issue	Mitigation Measure to Avoid or Minimize Impact
Oil and Chemical Handling	Potential spills	Develop prior to construction and implement oil and chemical spill prevention and cleanup plan. This plan will be similar to the spill prevention plan approved for the bulk sampling phase of this project and meet the applicable state and federal regulations.
Docking Facilities	New sites require additional roads and areas	Utilize existing area and road connection
	Deposition of fill materials harmful to juvenile salmonids	Utilize construction "windows" to avoid critical periods of fish use
		Utilize sheet piling with backfill to avoid loss of sediments

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facilities, and development of fish monitoring and tailings monitoring plans. Tentative agreement and understanding was reached on some of the items. Examples include the following: (1) the Wilson River well field has been dropped from the proposed project in favor of a supplemental water supply from the Blossom River; (2) modifications were made to plans for oil transfer facilities to assure compliance with U.S. Coast Guard requirements; (3) tailings and fish monitoring programs will be developed; and (4) restrictions will be followed concerning allowable construction periods and activities (e.g., blasting) in marine habitats. Where appropriate, revisions have been made in this EIS to reflect these changes. Resolution of other issues will require additional interagency discussion and will be formalized as part of permits required for the project. For example, the details for the fish monitoring program will be incorporated into the Forest Service Special Use Permit for the project.

The mitigative measures described in Sections 4.4.1 through 4.4.3 include those that have been reviewed and considered to date. They are keyed to specific impacts or groups of impacts. Wherever possible, the effectiveness, feasibility, and a general range of costs are estimated for each measure discussed. The discussion is conceptual for most measures, including those measures to be instituted at a later stage of the project. The methodology is specified only in general terms because technologies change.

4.4.1 Physical Environment

4.4.1.1 Air Quality

Fugitive Dust Reductions

As discussed in Section 4.1.1, the estimated fugitive dust emissions originate mainly from blasting, rock loading, haul roads, and rock dumping. The emission rates were calculated using the following assumed emission reductions: no haul road emissions on days with snow cover, partial emission reductions by gravity settling of large particles, 100 percent reduction in haul road emissions on days with measurable precipitation, and 85 percent reduction of haul road emissions by application of chemical binders during the dry season.

Additional reductions in fugitive dust emissions would be difficult and only marginally effective. Rock loading emissions could be reduced slightly by ensuring that the loaders drop the rock into the haul trucks from as low a height as possible. Methods to spray water onto the ore and waste rock as it is unloaded are probably not feasible. Permanent surfacing of the haul roads would reduce fugitive dust emissions, but such surfacing would probably be infeasible because of the extreme weight of the haul trucks and the temporary nature of the roads.

Permanent Townsite Emission Reductions

As discussed in Section 4.1.1.3, emissions from the alternative permanent townsites could cause ambient particulate concentrations in excess of PSD Class II increments. Wood stove emissions cause air quality problems at other Alaska towns that are topographically similar to the Bakewell townsite (Chapple 1984). At the Mendenhall Valley area near Juneau, Alaska, the ADEC has instituted strict regulations on emissions from wood stoves, and requires a total ban on wood stove use during periods of poor atmospheric dispersion. The population of Mendenhall Valley is much larger than the Quartz Hill townsite would be. However, the wood stove emissions of the townsite would probably be significant. It is likely that since primary space heating at the Quartz Hill permanent townsites would be provided by central electrical generators or line power, the ADEC might consider a ban on wood stove use as a requirement for issuance of air quality permits for the Quartz Hill project (Chapple 1984).

4.4.1.2 Natural Hazards

As discussed in Section 4.1.9, some impacts could occur due to avalanches, landslides, and earthquakes. During the construction phase, permanent avalanche control structures and an active avalanche control program would be in place to protect employees throughout the life of the project. Several mitigation measures would be employed to minimize impacts of landslides on the environment. These measures include revegetation of disturbed areas, immediate seeding and mulching of any landslide, hauling of landslide materials to an approved disposal site, and use of special blasting techniques. To minimize impacts of earthquakes, impoundments, embankments, and other structures would be designed and constructed to withstand effects of seismic activity.

4.4.2 Biological Environment

4.4.2.1 Freshwater and Marine Ecology

Background

Mitigation of project impacts on fish is defined in ANILCA Sections 505(a) and 505(b), which state in part that "The Secretary of Agriculture shall . . . maintain the habitats, to the maximum extent feasible, of anadromous fish and other foodfish, and to maintain the present and continued productivity of such habitat when such habitats are affected by mining activities on national forest lands in Alaska." Protection measures have been embodied in the operations plan for the project. The Secretary of Agriculture will review the plan annually to ensure that the goal of protecting fish and fish habitat is being achieved.

Recommendations concerning mitigation consider management agency mitigation policies and are based largely upon the results of a fish mitigation planning meeting held in Ketchikan, Alaska, on 21 October 1983. This meeting was attended by U.S. Borax, the Forest Service, the Alaska Department of Fish and Game, the National Marine Fisheries Service, and the Southern Southeast Regional Aquaculture Association.

These agencies prioritized the types of mitigation; the highest priority was to avoid the impact, lesser priority was to minimize or rectify impacts, and the least priority was to replace the impacted resource. These agencies also favored accomplishing the mitigation on-site or in-basin, within the stream or drainage where the impact occurs. The mitigation policies also favor "in-kind" mitigation, where the impacted species would be replaced by the same species. This would reduce disruptions to the system's ecology and harvest management problems.

Mitigation Procedure for Contingencies

The type of mitigation required for any impact will depend upon the type of impact, the extent of the impact, and the magnitude of the effects. For example, impacts from overharvest of fish and wildlife from increased fishing and hunting pressure are expected to be avoided through use of regulations by the Alaska Department of Fish and Game. Therefore, each impact needs to be well defined before specific mitigation measures can be identified. Sections 4.2.1 and 4.2.2 identify all potential impacts and provide an estimate of effects on the fisheries resources. In some cases, impact effects cannot be estimated because they would be within the natural range of variability. The following procedure will be adopted for developing mitigation measures.

<u>Identify Type of Impact</u> - Based on impacts identified in Section 4.2, three types of impacts requiring mitigation are:

- o Expected short-term impacts
- o Continuous or long-term impacts
- o Unpredictable impacts

Expected short-term impacts include impacts on freshwater organisms that stem from sedimentation caused during project construction. Losses of salmonids are expected to be minor, except during major disturbances, such as landslides. Because construction activities can be anticipated, the timing and location of potential impacts are known. Therefore, the degree of mitigation will depend upon the magnitude of an effect that can be measured during the construction period.

Continuous long-term impacts include impacts that persist as a result of the mine operation. Habitat losses and/or reductions in aquatic productivity could result from continued inputs of sediment from roads

and facilities, and from disposal of mine tailings. The magnitude of these impacts is estimated in Section 4.2, but the actual effect will need to be measured in order to provide the suitable mitigation measure from Table 4-43.

Unpredictable impacts are a result of events that potentially could occur during the life of the project but are unknown in terms of timing, location, and magnitude. Potential impacts could stem from such incidents as landslides, breaks in tailings pipeline, and spills of chemicals or petroleum products. Unpredictable impacts are likely to result in one-time fish kills and effects are likely to be short-term.

<u>Identify Extent and Magnitude of Impact</u> - In order to provide an appropriate level of mitigation for any impact, the extent and magnitude of the impact effects on the environment must be known. Potential impacts will need to be measured through an impact monitoring program. The monitoring program should be designed to detect changes in physical and/or biological parameters. Environmental changes that exceed some maximum acceptable level (as determined by the regulatory agency) would trigger a mitigation response plan. A mitigation response plan would provide the guidelines for implementing an appropriate mitigation measure that would be compatible with ANILCA 507(a). This should include an identification of the resource agency responsible for the impacted resource, a description of response time necessary to react and implement mitigation, and an outline of potential mitigation measures (e.g., Table 4-43) for the specific impact.

In the case of expected short-term impacts due to sedimentation during project construction, the appropriate monitoring program will include measurements of spawning gravel sediment levels during and after the construction period. If sediment levels exceed maximum acceptable levels (as determined by regulatory agencies), then a mitigation response would be initiated. In this case, the preferred response will be reclamation of the impacted habitat by gravel cleaning (see Section 4.4.6.3 for details). The necessary response time would be prior to the next spawning period and responsible authority would be the Forest Service and ADF&G. If egg losses occur as a result of the impact, an additional mitigation measure providing for replacement of the lost resource will be necessary. Lost production will be replaced by egg incubation boxes operated for one or more years (Section 4.4.6.3).

A mitigation response plan for continuous or long-term impacts could be developed for each potential impact (Appendix G, Table 17-1) and would follow a procedure similar to that needed for short-term impacts. An appropriate monitoring program (agreed upon by regulatory agencies) would be instituted to ensure environmental quality and to trigger a mitigation response should an unacceptable impact occur. Impacts known to be unacceptable ahead of time would be monitored to measure the magnitude of impact requiring mitigation. Measures suitable for mitigating these types of impacts are outlined in Table 4-43.

TABLE 4-43

FEASIBLE MITIGATION MEASURES, EFFECTIVENESS, AND COST FOR POTENTIAL IMPACTS ON THE AQUATIC ENVIRONMENT AS A RESULT OF THE PROPOSED AND ALTERNATIVE PROJECT COMPONENTS

Project Component	Habitat Impact	Potential Effects 1/	Potential Mitigation Measures 2/	Effectiveness 3/	Cost 2/
Road use	Sedimentation of spawning gravel	Appendix G, Tables 17-1a through 17-1h	1. Gravel cleaning	Greater than 50 percent reduction in fines	$\$0.22$-$\$1.25/yd^2$
			2. Egg incubation boxes	Average 80-85 percent egg survival to emergence using green eggs	$1,000/box
Sedimentation ponds in Hill and Beaver creeks	Suspended sediment	Appendix G, Tables 17-1a through 17-1h	1. Egg incubation boxes	Same as above	Same as above
Water use and drainage alteration of Beaver Creek	Dewatering	Appendix G, Tables 17-1a through 17-1h	1. Release minimum flow during critical period	Could provide up to 100 percent of needed flow	
Upper Hill Creek diversion	Channel alteration of North Creek	Appendix G, Table 17-1b	1. Habitat reclamation	Could replace 100 percent of former habitat	Less than $10,000
			2. Egg incubation boxes	Same as above	Same as above
Raspberry Creek reservoir	Dewatering	Appendix G, Tables 17-1d through 17-1f	1. Release minimum flow during critical period	Could provide up to 100 percent of needed flow	
Hill Creek reservoir	Dewatering	Appendix G, Tables 17-1g and 17-1h	1. Release minimum flow during critical period	Could provide up to 100 percent of needed flow	
Tunnel Creek tailings disposal	Habitat burial	Appendix G, Tables 17-1f and 17-1h	1. Spawning channel	Average 28 percent survival to emergence	$\$35$-$\$40/yd^2$
			2. Provide access (fishway) to inaccessible habitat	Could provide greater than 100 percent replacement of lost habitat	$1,000-$100,000
Aronitz Creek tailings disposal	Dewatering	Appendix G, Tables 17-1f and 17-1h	1. Locate outfall to provide ambient flow regime for lower Aronitz Creek	Could provide greater than 100 percent replacement of flow volume	
			2. Spawning channel	Same as above	Same as above
			3. Provide access (fishway) to inaccessible habitat	Same as above	Same as above

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TABLE 4-43 (Continued)

FEASIBLE MITIGATION MEASURES, EFFECTIVENESS, AND COST FOR POTENTIAL IMPACTS ON THE AQUATIC ENVIRONMENT AS A RESULT OF THE PROPOSED AND ALTERNATIVE PROJECT COMPONENTS

Project Component	Habitat Impact	Potential Effects 1/	Potential Mitigation Measures 2/	Effectiveness 3/	Cost 2/
Wilson estuary access road	Burial of intertidal habitat	Appendix G, Tables 17-1a through 17-1f and 17-1h	1. Creation of intertidal habitat	Creates community similar to natural	$25,000/acre
Keta estuary access road	Burial of intertidal habitat	Appendix G, Table 17-1g	1. Creation of intertidal habitat	Same as above	Same as above
Boca de Quadra tailings disposal	Burial of benthic habitat, increased turbidity of pelagic habitat	Appendix G, Tables 17-1a, 17-1b, 17-1d, and 17-1g	1. Mitigation (in kind) is not feasible		
			2. Artificial reef	Creates community similar to natural reef	$260,000/24 ac reef
			3. Creation of intertidal habitat	Same as above	Same as above
Wilson Arm tailings disposal	Burial of benthic habitat, increased turbidity of pelagic habitat	Appendix G, Tables 17-1c and 17-1e	1. Mitigation (in kind) is not feasible		
			2. Artificial reef	Same as above	Same as above
			3. Creation of intertidal habitat	Same as above	Same as above
Subtidal tailings line in Wilson Arm or Boca de Quadra	Habitat disturbance	Appendix G, Tables 17-1b through 17-1e, and 17-1h	1. Mitigation (in kind) is not feasible		
			2. Artificial reef	Same as above	Same as above
			3. Creation of intertidal habitat	Same as above	Same as above

1/ Fish or habitat losses are estimated for each alternative in referenced appendix tables.
2/ Information source and discussion of each measure in Section 4.4.6.3.
3/ Only includes beneficial effects of measure; source of information and potential negative effects are discussed in Section 4.4.6.3.

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The timing and location of unpredictable impacts (e.g., landslide or chemical spill) are unknown; thus, a monitoring program would not be feasible. However, a general mitigation response plan could be developed for the purpose of minimizing the environmental effects of an accident. The response plan includes, but is not limited to the following:

- Containment and neutralization
- Clean up of impact area
- Assessment of biological impact by regulatory agency
- Reclamation of disturbed habitat
- Replacement of fish loss, as described below

Identify Feasible Mitigation Measures - Measures suitable for mitigating each impact would need to be undertaken within the auspices of ANILCA 507(a) (for mitigation within the Monument) and the Joint Southeast Alaska Regional Planning Team (JSARPT) working in concert with the Forest Service and U.S. Borax. The JSARPT has already developed a long-term enhancement plan for the region (JSARPT 1981, 1983), and this EIS incorporates that plan by reference. Mitigation for the project will be compatible with the plan. Given these guidelines, a list of feasible mitigation measures (Table 4-43) is suggested for the potential impact of the proposed and alternative project components.

In addition to the measures listed on Table 4-43, requirements of the permitting agencies may be used to prevent or reduce potential impacts. For example, the ADF&G will not issue a fish habitat permit until the design of the Blossom River filtration bed is finalized. The precise location of the bed is subject to negotiation. Additionally, the ADF&G permit would be written with certain conditions, such as intake structure repairs taking place only during the winter.

Mitigation Measures:

Measures suitable for mitigating continuous or long-term impacts from the proposed and alternative project components are summarized in Table 4-43. Mitigation measures listed for each project component are technically feasible and considered most appropriate for the magnitude of impact expected for each project component (Appendix G, Table 17-1). A brief description of each mitigation measure, including effectiveness and cost of the measure, is provided below.

Gravel Cleaning - Spawning gravels clogged with sediment have been successfully cleaned by a number of methods, of which the bulldozer (Heiser 1972) and hydraulic gravel cleaner (Mih 1981) are most popular. All methods are effective in reducing the concentration of fines. In the lower Dungeness River, Washington, gravel cleaned by a bulldozer had a 90 percent greater survival of pink salmon fry than in an adjacent uncleaned area. Total project cost was about $0.16/m^2 (Reeves and Roelofs 1982). The effectiveness of gravel cleaning is best when the bulldozer is operated in high water. However, sediments dislodged from the cleaned area are washed downstream and would degrade other spawning habitat. This method is best suited for downstream areas.

The hydraulic gravel cleaner would reduce fines by greater than 50 percent and collect sediments in a hopper. Thus, the effects of washing sediments downstream are minimal (Cowen 1984). This method costs about \$0.22/m^2 (Andrew 1981).

Another method of gravel cleaning includes the tilling of gravel with a 5-ft-wide digging bucket, which relies on the stream current to sweep dislodged sediments downstream. Cleaning costs about \$0.60/m^2. Another procedure utilizes a screened bucket that is dipped in and out of the water while being vibrated. This method is slower than the tilling procedure and costs about \$1.25/m^2 (Andrew 1981).

Gravel cleaning by any of the above methods can have negative effects on the aquatic environment. The hydraulic gravel cleaner would dislodge aquatic invertebrates and result in a temporary (9 months to 12 months) decrease in invertebrate numbers (Meehan 1971; Allen et al. 1981a). The water velocity water jet has the potential of destroying nongame fish (e.g., sculpins and minnows) that utilize the rubble substrate for cover (Bailey 1981). Gravel cleaning would also cause high concentrations of suspended sediment downstream of the cleaning operation and may be detrimental to other aquatic habitats.

Egg Incubation Boxes - Streamside gravel incubation boxes are a cost-effective method of supplementing salmon production in streams. These portable units incorporate inexpensive wooden construction, a controlled water flow, and a clean gravel medium to improve survival of eggs by a factor of 5 times or more over natural production (Allen et al. 1981b). The Washington Department of Fisheries (WDF) has tested several designs and operation procedures, of which the 4 ft x 4 ft x 8 ft box proved most cost-effective. The WDF design requires 50 gal of water per minute, has a capacity of 0.4 mil coho or 0.5 mil chum eggs, and costs about \$1,000/box (Cowen 1984). Egg survival ranges up to 90 percent for eyed eggs and 80 to 85 percent for green eggs. The small capacity and portable nature of the boxes enable the use of indigenous stocks as an egg source and circumvent genetic or pathologic concerns. At Quartz Hill, egg boxes could be placed along the lower Wilson or Blossom rivers and water supplied from the Blossom River pumping station. This would be a low cost means of replacing salmon losses if project impacts become significant.

Habitat Reclamation - Habitat reclamation of lower North Creek (for example), would require structures that stabilize the stream channel, promote pool development, and provide retention of spawning gravel. Rock-drop structures, gabions, and log weirs have been successful in providing spawning and rearing habitat for juvenile salmonids (Hall and Baker 1982; Reeves and Roelofs 1982). These structures are usually imbedded in the stream bed perpendicular to stream flow. The structures control stream gradient by forming a series of steps in the longitudinal profile of the channel. Above each step gravel collects and forms a spawning area, and below each step the concentration of stream flow scours out pools that are utilized as rearing habitat. Log weirs placed in a channel scoured to bedrock by a debris torrent in the Queen Charlotte Islands, B.C., increased the number of pools and

resulted in a significant increase in smolt production (Tripp 1984). Total cost of rehabilitation was less than $2,000 for placing log structures in a 250 m stream reach. Costs would vary depending upon access for heavy equipment and accessibility of construction materials. Reclamation of the 800 m reach of North Creek accessible to anadromous salmonids would likely cost less than $10,000.

Spawning Channel - A spawning channel is a man-made stream designed to provide the best possible environment for spawning and incubation. An artificial spawning channel increases spawning habitat and optimizes physical conditions such as flow, substrate size, sedimentation, and production so that egg-to-fry survival is improved. In a natural stream, survival from egg-to-fry averages 10 to 15 percent, whereas survival in a spawning channel has been 30 to 80 percent (JSARPT 1981, p. 72). The cost of a spawning channel would depend upon channel size and difficulty of construction. In general, cost would average $35 to $40/yd^2. A new channel constructed by the Northern Southeast Regional Aquaculture Association on the Chilkat River cost $123,000. The spawning channel is 1,500 ft long by 20 ft wide and has a capacity of 5 to 6 million chum salmon eggs (Bachen 1984). The Chilkat spawning channel is built on an old river bed where groundwater upwelling provides a constant water supply. A channel of similar design may be feasible for the lower Wilson, Blossom, or Keta rivers. If suitable groundwater is not available, a side channel diversion or water from the supplemental water supply could be used for a spawning channel. Spawning channels require periodic maintenance for cleaning of spawning gravels and servicing of water control structures.

Fishways - Fishways and barrier modifications can provide fish access to spawning and rearing habitat and result in enhancement of indigenous salmon stocks. Passage projects have ranged in magnitude from simple blasting of falls and barriers to the construction of massive fish ladders. Fish passageway improvements have been done on about 18 southeastern Alaska streams in recent times: 8 barrier modifications and 10 steep passes or ladders. Costs of projects have ranged from under $1,000 to over $100,000 (JSARPT 1981, p. 183). Fish passageways have had moderate success and in some cases complete failures have resulted. The introduction of anadromous salmonids into resident salmonid areas can have detrimental impacts on the resident fish population. Therefore, the biological implications of providing fish passage must be considered before a passageway is constructed.

In the vicinity of Quartz Hill, several rivers contain suitable habitat located above fish barriers (i.e., Wilson River, Marten River, and Dicks Creek). Surveys by the U.S. Forest Service on the Marten River and Dicks Creek indicate that 36 ac and 34 ac, respectively, of salmon habitat could be provided if existing barriers are modified for fish passage (Barber 1984b).

Creation of Intertidal Habitat - The placement of fill into deep water areas adjacent to river deltas can be used to develop new intertidal or tidal marsh habitat. Also, the grading of steep banks can be used to develop a larger intertidal zone. This type of habitat enhancement is relatively new in the Pacific Northwest and is being investigated in

British Columbia as a means for enhancing juvenile salmon habitat. Dredge materials were utilized to construct four islands (total area 10 ac) off the mouth of the Campbell River, Vancouver Island. Marsh plants were transplanted and a vigorous plant community has developed within two years. Utilization of the marsh habitat by outmigrating juvenile chinook and chum salmon is extensive. Total cost for construction of the project was $250,000 (Brownlee 1984).

At Quartz Hill, waste rock from the mine site and road construction could be used to increase the size of the Wilson estuary or Keta estuary intertidal habitat as mitigation for burial of the upper tidal marsh by an access road. Endemic marsh plants could be transplanted to the new site in order to create a habitat similar to the existing marsh. The marsh site would be colonized by marine fish and invertebrates, and could be used as a feeding area for outmigrating juvenile salmonids.

Artificial Reef - An artificial reef is constructed from the placement of material (e.g., tires, waste concrete rubble, or discarded equipment) on a flat sand bottom to create heterogenity in bottom topography. Artificial structures create a diversification of habitat that results in an increase in fish species and fish density. In Puget Sound, the average density of fish adjacent to man-made structures was almost four times greater than that observed over an open sand bottom and the biomass about seven times greater (Walton 1979). The Washington Department of Fisheries has found that it takes approximately 10,000 yd^3 of concrete material scattered in piles over a 24-ac site to make an artificial reef adequate to accommodate a recreational fishery with its large number of participating boats. Current cost for construction of an artificial reef in Puget Sound is approximately $260,000, with much of the cost going to barge transportation of the concrete material (U.S. Fish and Wildlife Service 1982, p. d-2).

Although no feasible method is available to directly replace lost deep benthic habitat, placement of artificial reefs in Wilson Arm or Boca de Quadra is a feasible form of mitigation for the loss of deep water habitat during tailings disposal. To be effective, however, such reefs should be sited and developed on the basis of past studies (e.g., Huckel and Buckley 1982; Laufle 1982; Walton 1979).

At an interagency mitigation and monitoring meeting held in Juneau on October 15-16, 1987, the idea of creating artificial reefs was not supported as a mitigation alternative. It is, however, incorporated here to indicate that this alternative was considered in the planning process.

4.4.2.2 Wildlife

Final project development alignments should maintain as large a buffer as possible between the development and existing bald eagle nests. Approximately 10 to 20 eagle nests are within 0.5 mi of proposed

facilities, depending on the alternative selected. If the planned project facilities are within the 100-m (330-ft) buffer zone that is required around eagle nest trees (as per the Memorandum of Understanding between the U.S. Fish and Wildlife Service and the Forest Service [1984]), it will be necessary to obtain a variance from the U.S. Fish and Wildlife Service to construct the facility within the buffer zone. Construction and other activities within the buffer zone would be prohibited during the nest establishment period (March 1-April 30). If the nest is occupied, construction and other activities within the buffer zone of that nest would be prohibited during the egg laying, incubation, and rearing periods (April 30-August 31). An "eagle action plan" (Forest Service 1983c) guided the construction of the bulk sample access road, and such a document will be developed for project development. It will prescribe restrictions on construction activities and the monitoring requirements.

Personnel will be strictly prohibited from feeding animals or leaving edible materials in construction zones in order to prevent attraction of bears. These requirements are currently mandated by state statute. Garbage should also be collected and incinerated daily to prevent attraction of bears. It is required that U.S. Borax regulate and limit use of firearms by work crews on-site to defense of life or property in order to minimize loss of wildlife. Additionally, personnel will be cautioned to drive at a safe rate of speed to reduce accidental collisions with big game and other species.

Since the project will cause reductions in populations of several wildlife species (especially mountain goats) that cannot be prevented if the project goes forward, mitigation measures are limited. It is not feasible to replace lost animals in the project area, so the most logical choice is to replace them elsewhere.

Up to the present time, U.S. Borax has provided some funding for goat baseline studies at Quartz Hill and donated $1,000 to the Alaska Sports and Wildlife Club for the Revilla Island goat transplant project to establish a population in previously unused habitat.

If other unused goat habitats exist and are approved, future goat transplant projects will be funded by U.S. Borax to mitigate losses to goats and goat habitat at Quartz Hill. If a mountain goat transplant proves successful, and it is subsequently determined by field surveys that more than 100 percent of the loss to mountain goats has been compensated for, this excess could potentially be negotiated as mitigation for other wildlife losses when species-for-species compensation proves infeasible. However, whenever practical and prudent, "in-kind" mitigation should be attempted and transplants must prove successful before mitigation is negotiated.

A recommended transplanting program would include moving a minimum viable starter population of goats in the first year, monitoring their success by way of radio collars and aerial surveys, and adding a small number of additional goats the second year to replace lost or weak

goats. The estimated minimum viable population consists of 5 males and 10 females. Additional goats would be added in a 1:1 ratio of males to females. Therefore, in the first year, about 15 goats would be moved and the second year an estimated 5 to 7 additional goats would be moved.

The cost of moving the goats includes operating costs ranging from about $1,000 to $1,500 each if they are equipped with radio collars, or about $800 to $1,000 each without radio collars, and work force costs of about 10 manhours per goat (Smith 1984a). The total cost of the recommended program might range from about $25,000 to about $40,000.

Ideally, mitigation for unavoidable mortalities should come in the form of the replacement of affected resources or environments. But, recognizing that some losses are unmitigatable in a direct manner, another option to out-of-kind mitigation may be monetary compensation to help fund the state's priority wildlife programs. Some figures and formulas have been developed to help quantify the economic values of certain individual wildlife, and would perhaps be of use in determining compensation for unmitigatable losses to wildlife in this project.

Discussion meetings have already taken place between U.S. Borax and the responsible agencies. One meeting was held October 21, 1983 in Ketchikan, Alaska, and another was held in Juneau on October 15-16, 1987. The meetings were attended by ADF&G, Forest Service, and U.S. Borax representatives, as well as others, and the mitigation recommended here was based on consideration of the views expressed in those meetings.

4.4.3 Social and Economic Environment

4.4.3.1 Socioeconomic Mitigation Measures

This section describes mitigation measures that could reduce or avoid project-related impacts on the City of Ketchikan, City of Saxman, and the Ketchikan Gateway Borough. The timing of implementation would vary. Local hire programs would precede project development, while other programs would be implemented during the construction phase. In order to make a determination of the expected impacts, a monitoring program will be devised to track certain indicators of socioeconomic impacts, such as school enrollment and housing starts.

In order to develop appropriate mitigation measures, the impacts that are a direct result of the project must be separated from those impacts associated with other forces also causing change. Many of the services and facilities are already being "impacted" by baseline growth. The costs to bring these services and facilities to the appropriate levels to meet the existing demand cannot be attributed to the Quartz Hill project.

The types of measures that can be considered for inclusion in an impact mitigation plan fall into three general categories:

1. Measures to minimize demands on local economic, social, and governmental systems;

2. Measures to enhance the capacity of local systems to cope with change; and

3. Measures to compensate individuals or groups.

The first type of measure pertains to controlling the size of the in-migrating work force by maximizing the number of workers hired locally. These measures are also a means to enhance economic benefits to the local area. One method for increasing the number of local hires is to implement job training programs for local residents. The second type of measure pertains to provisions by the developer of housing and support infrastructure to accommodate the in-migrating population. Compensation measures can be defined as those mechanisms that provide monetary payments or other forms of recompense for project-induced costs or losses. These measures could include job opportunities and improved community facilities for native Alaskans to offset any intangible costs such as disruption of cultural values and lifestyle.

Measures to manage growth would need to be undertaken by the Ketchikan Gateway Borough. While not mitigation techniques in the strict sense, use of building codes, zoning, subdivision regulations, building inspections, and facility planning would complement mitigation measures implemented by U.S. Borax. The measures listed in Table 4-44 are identified by type of impact, affected option, and the objective of the measure.

Following the close of public comment for the Draft Environmental Impact Statement, the community (City of Ketchikan, City of Saxman, and Ketchikan Gateway Borough) and officials of United States Borax a Chemical Corporation began discussing means of implementing socioeconomic mitigation measures. The local government bodies assigned their respective managers as negotiators with a 5 person liaison committee (2-Borough, 2-Ketchikan, 1-Saxman) to provide direct communication and advice between the elected officials and the negotiators. U.S. Borax provided their Ketchikan Manager as their primary negotiator, with the Vice President/Project Manager available as needed. All of the principals involved intend and expect the negotiated mitigation agreement to be approved in its final form at the Assembly/City Council(s)/Corporate President level.

Negotiations have been completed among the affected parties. The Memorandum of Understanding, signed by the three Mayors of the Community and the President of U.S. Borax, demonstrates the commitment of the affected parties to achieve solutions to the impacts of the project and turn the opportunities into advantages. A copy of the MOU is presented in Appendix I. The MOU establishes a process for reaching agreement between the Community and U.S. Borax through which it may be

TABLE 4-44

SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
1. Quartz Hill will produce economic and social changes in the Ketchikan area.	To lessen the negative impacts of the Quartz Hill operation through appropriate planning.	Planning for impacts.	Commute, Phase-in	Hire Impact Specialist to monitor changes in the community in order to determine the Quartz Hill impacts. Act as liaison between the community and U.S. Borax in implementation of mitigation measures.	Isolate impacts attributable to Quartz Hill project from impacts associated with other changes.
				Secure impact funds from the state as available for technical assistance for implementation of mitigation measures.	To reduce financial burden on local area.
			All	Set up a monitoring program to track the project-related impacts. Establish a statistical baseline for the year prior to construction. Baseline data should include population, employment, occupied housing units, school enrollment, local business revenues, governmental expenditures and revenues, and use levels for public services and facilities.	To isolate impacts attributable to Quartz Hill.
2. Quartz Hill will bring with it a large number of job seekers and their families, as well as adventure seekers to the Ketchikan area.	To reduce or eliminate negative impacts associated with a large number of employment seekers.	Job seekers may be entering Ketchikan in large numbers.	All	Develop a "publicity plan" to discourage in-migration of unemployed, as well as an excessive number of qualified, job seekers to the Ketchikan area.	Increase local hire and reduce in-migrating population.

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TABLE 4-44 (continued)

SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
2. (Continued)				Determine and monitor trends of in-migration and the effects of transient influx on the community.	To provide a current measure and awareness of trends evident in the community prior to and during the development of Quartz Hill.
3. Employment and income benefits of Quartz Hill should be contained within the Ketchikan Gateway Borough to the extent possible.	To ensure that local residents and businesses benefit equitably from the Quartz Hill project.	Ketchikan area residents may either be qualified and overlooked or not have the requisite skills to fill jobs at Quartz Hill.	All	Monitor local hiring during construction and first 5 years of operation.	To provide input to local hire program for operations phase.
				Initiate vocational training at the high school and community college compatible with U.S. Borax needs.	To allow local residents, especially youth, to become sufficiently skilled in the vocational fields appropriate to Quartz Hill operations.
				Make local residents aware of available jobs, job requirements and qualifications, job application processes, and available career paths well in advance of construction phase.	To allow local residents opportunity to obtain appropriate job skills for employment at Quartz Hill.
				Develop and circulate a pre-application form in Ketchikan in order to establish a roster of qualified local residents.	To give priority of employment to local residents.

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TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
3. (Continued)				Develop and maintain a cooperative salary survey program to ensure that salary levels in the community are competitive but stay "in line."	To assist in the recruitment and retention of well-qualified personnel to fill local positions vacated by changing markets in the community. To assure that a basis for salary administration for the community is established.
		Minority groups may be left out of the potential job market.	All	Establish hiring policies to encourage minority hire in accordance with EEO and work with City of Saxman and Ketchikan Indian Corporation, the Filipino Community of Ketchikan, and any other minority organizations to implement procedures to screen potential applicants.	To offset cultural impacts to minority Alaskans.
		Local businesses may not be able to compete effectively with larger businesses from outside of Alaska in providing for the increased demand on consumer and business supplies.	All	Provide an annual procurement plan that identifies the quantity of local goods and services that could be purchased.	To enable local businesses to compete more efficiently for contracts to provide materials, supplies, and services to the project.
				Work with local business groups to set policies and procedures to maximize local business opportunities.	To maximize local business opportunities.
				Monitor level of business done by local firms with U.S. Borax.	To determine if the local business community is providing competitively priced services and materials and to enhance local economic benefits.

TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
4. The Quartz Hill project should not affect negatively the cost of living to area residents.	To maintain a cost of living that parallels southeast Alaska during the life of the Quartz Hill project.	An influx of highly paid workers, as well as increases in the demand for goods in a community with limited supplies, could cause a relative decrease in standard of living for area residents.	All	Collect baseline information and monitor cost of living changes during construction and first 5 years of operation.	To measure impacts on people with low and and fixed incomes.
				Implement strategies that will assist those persons affected adversely by an increase in cost of living.	To maintain quality of life for all area residents.
5. The quality of life and social well-being of the area residents will be affected by the quality of housing available.	To assure maintenance of sufficient quantity and appropriate quality of housing for area residents.	An influx of people into the area could place excess demands on the housing market.	All	Develop a "Housing Demand Plan" specifying timing, location, and type of housing required.	To prevent overbuilding and building in undesirable locations.
				Institute land disposal, zoning, and planning processes favoring multi-family housing.	To prevent urban sprawl.
				U.S. Borax guarantee to buy homes of employees unable to sell in the event of early mine closure.	To minimize risk of home purchasers.
				Institute housing assistance program for workers, including mortgage assistance, interest differential payments, and buy back guarantees, should the facility close prematurely.	To minimize risk of home purchasers.

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TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
5. (Continued)					
				Provide housing in the KGB in the event of a housing shortage.	To ensure housing needs are met to avoid over-building.
				Guide the location of housing development by making appropriately zoned, fully serviced borough-owned land available to housing developers.	To ensure quality building construction.
			Phase-in	Lease mobile homes to provide housing needs for temporary Ketchikan residents.	To ensure housing needs are met to avoid overbuilding.
		Rapid growth could result in substandard building leading to poor quality housing.	All	Adopt and enforce uniform building codes.	To ensure quality building construction.
				Subsidize a building inspection program required for that portion of growth that is above baseline.	To prevent new substandard housing construction.
				Provide the required guarantee funds to construct housing or commercial projects through City and Borough LID procedures.	To reduce the financial demands on the community and encourage quality housing development.
				Develop strict sub-division regulations with strict specifica-tions on road construc-tion and provision of public services.	To assure a quality living environment.

TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
5. (Continued)			Commute, Phase-In	Develop housing for workers to ensure proper housing mix and quality housing development.	To assure quality living environment and to keep housing costs down.
				Remove from the community all temporary housing and mobile homes if constructed or installed.	To assure quality living environment.
6. The quality of life will be related to the availability of adequate facilities.	To maintain the health and social well-being of the area residents.	Rapid building could result in substandard water and sewer systems.	All	Raise standards for installation of new water and sewer systems.	To minimize water quality and health hazards.
				Install water meters in the community and develop a program to bury existing water and sewer lines at sufficient depth to prevent winter freezing.	To increase capacity of present potable water and sewer systems of reducing "winter water waste" and to provide funding for necessary improvements to water and sewer systems.
				Organize quick response teams using existing fire departments for recruiting and training personnel volunteers.	To be prepared for medical emergencies.
		Strain on emergency medical care.	All	Provide primary medical care at the mine.	To assure for the health and safety of mine employees and visitors.
		Inadequate fire fighting capabilities in areas lacking adequate water systems.	All	Develop a fire protection master plan for the Ketchikan Gateway Borough.	To reduce fire risk in ne housing developments.

TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
6. (Continued)					
		Shortage of recreation facilities.	All	Construct new recreational facilities and plan programs within the KGB.	To provide adequate outlets for the recreational needs of residents.
				Provide limited recreational facilities for U.S. Borax employees.	To minimize the demand on current public facilities.
				Impose a requirement mandating the development of neighborhood parks in LID developments.	To minimize the financial burden on the local property owners.
				Establish a land bank for future recreational community development. Purchase land within the borough and dedicate it to future recreational development.	To offset the shortage of parks in the borough and to ensure that land for this need is set aside before development occurs.
				Develop a park and recreation master plan.	To ensure that parks and recreation facilities are adequate for a rapidly growing community.
		Shortage of schools.	All	Contribute to the cost of new elementary school and additions or alterations to secondary schools in proportion to magnitude of impact.	To reduce financial burden on the community of providing adequate educational facilities.

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TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
6. (Continued)					
			Phase-In, Town-site	Provide portable classrooms.	To reduce overcrowding in schools.
					To ensure smooth transition from Ketchikan to townsite.
		Shortage of boat slips.	Commute	Secure state funds as available to accelerate development of a new harbor.	To minimize overcrowding of existing harbors.
			Phase-In, Townsite	Secure state funds as available to expand open moorage area.	To minimize overcrowding of existing harbors.
			All	Contribute to building and maintenance of boat harbors in proportion to the magnitude of impacts.	To reduce financial burden on state and community.
		Law enforcement shortages.	All	Fund extra law enforcement required by project.	To ensure public health and safety. To reduce the financial burden on the community.
		Traffic congestion in downtown area.	All	Support the development of public transit to reduce volume of traffic.	To provide for the safe and easy passage of traffic.
7. The quality of life is related to availability of adequate and appropriate social services.	To provide the necessary social services to the residents of Ketchikan area.		All	As part of an Employee Assistance Program include alcoholism, substance abuse, and mental health treatment in medical insurance coverage.	To compensate social service agencies for their services.

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TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
7. (Continued)					
				Develop policies regarding substance abuse on the job.	Reduce impacts on social service agencies and quality of life in Ketchikan.
				Develop and provide mini-courses in the area history, Alaskan history, and cultures.	To help newcomers adjust to and assimilate into the community. To promote a sense of community among newcomers.
				Increase number of museum tour guides and related staff.	To provide an adequate museum staff to serve the community.
				Increase funds available for libray materials from sources other than property tax (e.g., "Friends of the Library Fund," contributions from U.S. Borax, etc.).	To maintain quality library services for all residents without undue hardships on in-city property owners.
				Establish a community facility for drug-dependent cases, and a detoxification center to provide care and assistance.	To be prepared to address the increase in alcohol and drug-induced problems that could occur.
				Secure additional professional staff to operate in emergency and crisis response and intervention services.	To be prepared to address the increase in alcohol and drug-induced problems that could occur.

TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
7. (Continued)					
				Develop programs within schools and community that would educate children and adults on substance abuse and alcoholism.	To lessen instances of substance abuse through education at all levels.
				Increase staffing of social service agencies to meet project-related needs.	To compensate for additional impacts on social services.
8. The increased demand for public services and facilities put a strain on the financial resources in the community.	To lessen the overall financial impact of the Quartz Hill development on the community and state.	Revenues for funding of infrastructure.	All	Institute or increase sewer and water hook-up fees, establish or increase sewer and and water user fees, and transfer revenues to city general fund.	Shift some of financial burden to newcomers.
				Retain a qualified and experienced municipal financial consultant to assist the governmental staff in developing a report that identifies all major additional revenue sources available to the community.	To be informed of all revenue alternatives.
				Consider policies that require developers to pay for basic community improvements required because of growth such as fees for utilities, parks, schools, and dedication of open space for greenbelt and parks.	To shift financial burden to housing developers and newcomers.

TABLE 4-44 (continued)
SOCIOECONOMIC MITIGATION MEASURES

Issue	Goal	Impact	Affected Options	Implementation/ Mitigation Measure	Objective
8. (Continued)					
				Make a thorough assessment of the community's bonding capability prior to contemplating any long-range financing.	To be informed of bonding and long-term financing alternatives.
				Underwrite borough and city loans for infrastructure improvements resulting from project-related growth not covered by revenues from project-related taxes.	To shift financial burden to project proponent.
				Prior to construction of developments, create local improvement districts to follow development plans and assess costs.	To reduce the financial burden on the local community.
			Commute	Secure state or federal grants as available to pay front-end public service requirements.	To reduce financial burden on local community.

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possible to determine the impacts judged negative by the Community, and what type of measures they consider adequate to mitigate them. This would complete the process of identification and analysis of potential social and economic impacts and possible mitigation measures.

Once a decision has been made to start the Quartz Hill project, existing data will be reviewed to determine whether the baseline conditions and anticipated impacts presented in the EIS are appropriate. Revisions will be made where necessary. This, and other pertinent data, will be used as baseline information to evaluate impacts during monitoring. As impacts are encountered or become easier to anticipate (due to the shortened time frame between study and impact), borough, community, and U.S. Borax representatives will determine the mitigative measures to be taken. Federal and state funds will be utilized as available, and the committee will decide upon funding of the remaining measures. The MOU procedures and the commitment of the committee representatives provide a strong framework for mitigating impacts in a timely and mutually agreeable manner.

4.4.3.2 Cultural Resources

An intensive field survey in advance of development activities will be required to locate and identify the cultural resources that may be affected.

Sufficient data will be gathered from each identified resource to evaluate their significance according to criteria set forth in 36 CFR 1202 and 1204. Adverse effects upon significant cultural resources will be mitigated by redesigning an activity to avoid the resource or by salvaging the information contained in the resource before an activity affects it. In the case of indirect impacts, such as potential for damage due to improved access or increased population, education of the public in the cultural value and fragility of the resource may be sufficient mitigation.

The cost of conducting an intensive field survey would range from about $100,000 to $200,000. There would be a high likelihood of uncovering a resource near the shoreline during that survey, but little likelihood at higher elevations. Additional resources could be uncovered at some future date in areas along the coast if new excavation occurred.

4.4.3.3 Land Use and Recreation

Most land use and recreation impacts would be unavoidable if the proposed project were developed, and not particularly amenable to mitigation. However, the magnitude of some impacts could be reduced by certain measures, and the potential for others could be lessened. Responsibility for these mitigation measures would rest with either U.S. Borax or the Forest Service.

Proposed Project and Alternatives

- Project-related operations could be planned and scheduled to minimize effects on recreationists using the Monument wilderness, particularly the Winstanley-Wilson Lake area. Air travel (especially helicopters) could be restricted to routes away from this area. To the extent possible, traffic and other noise producing activities could be scheduled for daylight hours during the week. However, changing the schedule could severely hamper project operations and could therefore be costly. This measure pertains to all of the alternatives. Careful scheduling of project-related operations would be most effective during the summer months when recreation activity is the highest. The cost associated with implementation of this measure cannot be estimated until detailed information on operations is available.

- U.S. Borax could educate project workers about the sensitivity of the local recreation environment. The company could prohibit use of project aircraft to transport workers to recreation sites, and could encourage workers to confine their after hours recreation to facilities at the camps. This measure would contribute to the reduction of impacts on wilderness values and wildlife habitats. The cost associated with adopting this policy is expected to be minimal.

- The Forest Service could develop an education and information program designed to more evenly distribute use throughout the Monument, and inform users of potential noise and other effects in the project area and the Winstanley-Wilson Lake area. The agency could also develop a program for more accurate and comprehensive monitoring of recreational activity, such as by seasonal rangers stationed in the Monument, periodic observation flights or boat trips, coordination of observation with other business related trips, and similar means. Similar to the measure mentioned above, education and information programs would contribute to the reduction of impacts on wilderness values and wildlife habitats. There would be a cost associated with this measure, and it would depend primarily on staffing requirements.

- The Forest Service could provide additional cabins, trails, shelters, and buoys within the Monument, sited so as to encourage use distribution; U.S. Borax could provide financial assistance. This measure would help to shift recreational use away from the project area. The cost of installing an additional cabin would be approximately $30,000 and the cost of developing a trail in new territory would be approximately $20,000 per mile. This cost estimate does not include the cost of building bridges.

Townsite Options

- The Forest Service could permit only a lease arrangement, with no private ownership at the townsite, and could also agree to maintain stringent land use control. Continuation of the current Monument and wilderness designations could be stipulated and incompatible new land uses not permitted.

- Recreation measures involving information programs, monitoring, and facility development as described above could also be employed for townsite development.

- Planning and design for the town could include low intensity outdoor recreation development in nearby areas that would seek to help concentrate use near the town and direct it away from the Rudyerd Bay area.

4.4.3.4 Aesthetics

Mitigation measures that apply to the proposed project will be implemented during project construction to reduce visual impacts. Information presented in Table 4-45 designates the housing option each mitigation measure pertains to, the expected effectiveness of the measure, and incremental cost.

4.5 MONITORING

A description of monitoring plans is presented in this section. Specific details of monitoring plans will be developed during the project permitting process.

The Forest Service is responsible, under provisions of ANILCA subsections 505(a) and 503(b)(3), to assure the continued productivity of the habitat of anadromous fish and other food fish and to prevent significant adverse environmental impact to the fishery habitat. To meet that responsibility, Forest Service personnel will monitor construction and operation activities to ensure compliance with design and permit conditions. Additionally, the Forest Service will take the lead role in the development and implementation of a monitoring plan and will coordinate these efforts with other resource agencies.

The need to monitor various aspects of project construction, operation, and completion will be an important component of the permitting process. One of the key permits will be the Forest Service Special Use Permit. In addition, numerous other permits and approvals (see Table 1-1) will also have monitoring requirements. At the multiagency meeting held in Juneau on October 15 and 16, 1987, it was generally agreed that as more impacts are avoided through mitigation, planning, and project design, there will be less need for monitoring. (Methods to mitigate project impacts were discussed in Section 4.4.)

Monitoring is generally required for four major reasons:

a) Compliance monitoring
b) Prevention of impacts
c) Detection of impact events or thresholds
d) Determination of the success of mitigation measures

Compliance monitoring is directly related to the federal, state, or local permits. For example, water samples will be taken in Wilson Arm in the vicinity of tailings discharges to assure that water quality

TABLE 4-45

AESTHETICS MITIGATION MEASURES

Measure	Affected Option	Effectiveness	Additional Cost
Retain the natural vegetation to provide screening, especially along shorelines.	Townsite	Will minimize the contrast with disturbed areas and draw less attention to the man-made structures.	Minimal
Avoid the use of reflective construction material in the project facilities.	All	Will reduce the range of visual impacts, including viewing from aircraft, created by the Wilson wharf facilities and portal area. Will help to reduce the degree of visual impact and achieve, to the extent possible, a level of landscape alteration that corresponds with Forest Service visual quality management objectives.	Minimal
Use natural colors in painting structures to blend with the surrounding landscape.	All	Same as above	Minimal
For the access road between Bakewell townsite and Wilson Arm, contour slopes to minimize sharp horizontal lines.	Townsite	Will help to retain the slope characteristics of the natural terrain.	Costs depend on site-specific variables.

standards of the NPDES permit are met. If the standards are not met, corrective actions, such as changes in operational procedures or project shutdown, will be taken.

Monitoring of certain project aspects will be used to prevent possible impacts. For example, the discharge pipeline will be routinely examined to identify and repair any weaknesses, preventing pipeline failure and the associated tailings spills.

Although analyses are used to predict some project impacts with a reasonable level of confidence, a level of uncertainty may still exist as a result of the assumptions used in the prediction. Therefore, monitoring may be needed to determine if events and impacts are within the thresholds or levels predicted. For example, U.S. Borax has agreed to monitor the behavior of tailings disposal in Wilson Arm/Smeaton Bay to determine if it matches modeling results. If not, other alternatives may be needed to avoid impacts that could occur if the threshold is exceeded. For example, U.S. Borax has suggested several potential alternatives if monitoring shows a divergence from predicted behavior or impacts of the tailings in Wilson Arm/Smeaton Bay. These alternatives are as follows:

- i) Increase the seawater dilution ratio at the outfall;
- ii) Provide a deeper outfall;
- iii) Move the outfall downfjord;
- iv) Change the suite of milling reagents.

More drastic measures include the following:

- i) Shut down the mine;
- ii) Examine the extent of tailings losses to Behm Canal;
- iii) Shunt tailings to Boca de Quadra;
- iv) Land disposal;
- v) Ocean disposal.

Mitigation measures have been developed to reduce the impact of certain aspects of the project. For example, road construction practices include measures to prevent erosion and sedimentation in order to avoid or minimize impacts to fish habitat in project streams. To assure that mitigation practices are achieving their goal, monitoring of specific fish resources (e.g., escapement to the Blossom River) will be used as a measure of success.

A multiagency team has been assembled to develop and recommend a fisheries monitoring plan for the Quartz Hill mine. This monitoring plan will fulfill Section 505 of ANILCA, and provide the information necessary to monitor the habitat conditions and productivity of the fisheries resource in the areas potentially affected by mine development and operation. Members of the development team include the U.S. Forest Service, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Alaska Department of Fish and Game, Southern Southeast Aquaculture Association, and U.S. Borax. The objective of

the monitoring plan is to provide guidance on how to monitor effects of mine development and operation on the continued productivity of anadromous fish, other food fish populations, or fishery habitat.

After review by the EPA, the monitoring plan will become part of the environmental monitoring required by the NPDES permit. To fulfill its objective, the multiagency team will prepare a plan that is the following:

1) Sufficiently detailed and site specific, so that natural changes can be differentiated from those caused by mine operations;

2) Implementable within the considerations of available technology, manpower, and budget;

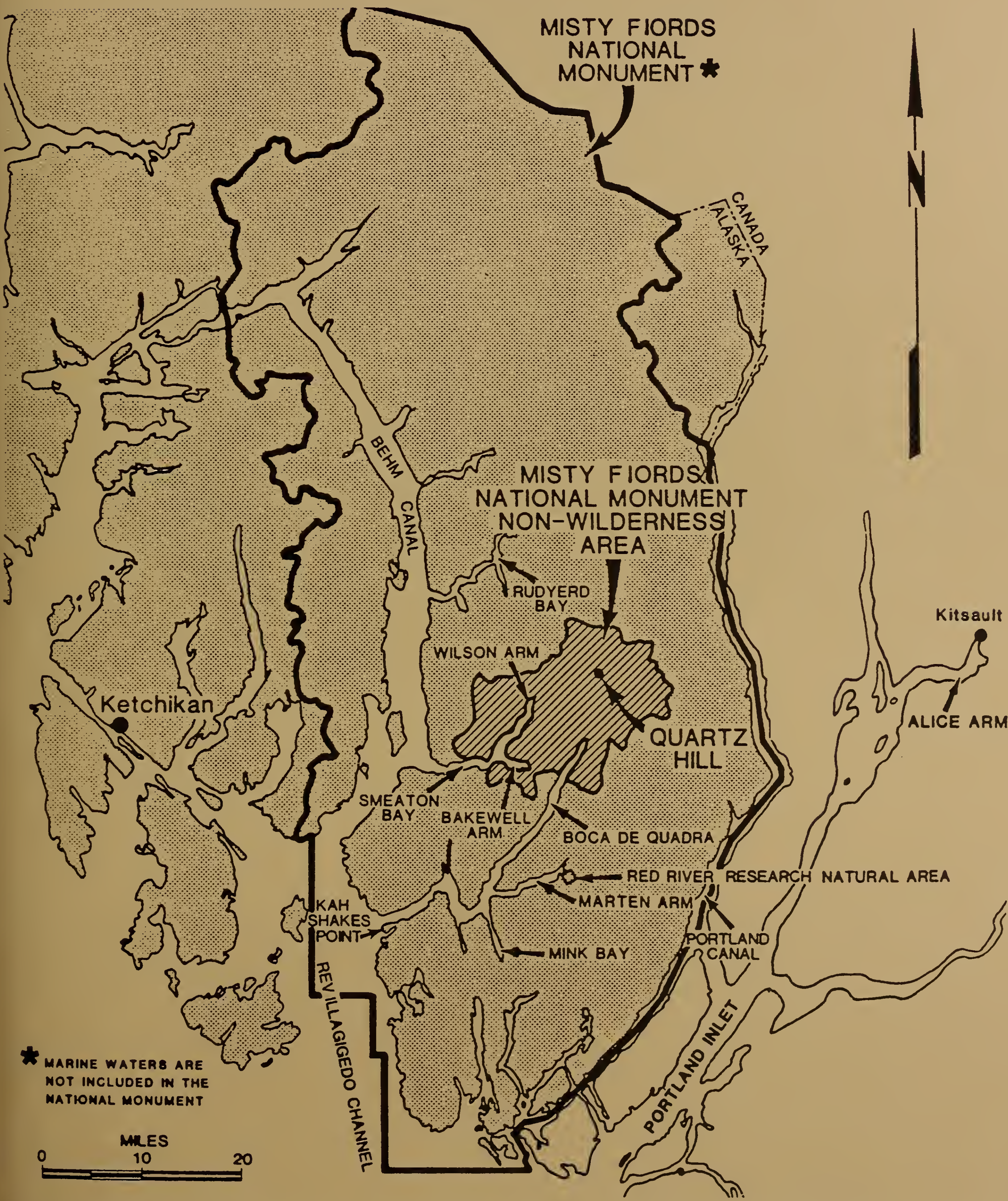
3) Flexible enough to maintain efficiency and effectiveness; and

4) Focused on the earliest possible detection of changes.

The monitoring plan will have sections that address the marine and freshwater environments. Each of these sections will focus both on habitat components and general species productivity. As appropriate to each specific section, habitat monitoring will evaluate water quality, water quantity, major food sources, and/or the presence of toxins. Productivity monitoring will focus on "target species," that is, those of commercial or economic value, or significant current or potential human use. The list of target species for the monitoring plan are the five species of salmon (chinook, coho, pink, chum, and sockeye), pacific herring, dungeness crab, and shrimp. The productivity of these species will be monitored to evaluate the overall effect of mine development and operation. Escapement counts will be the method for monitoring the salmonids. Catch-per-unit effort, density estimates, or population structure will be used to evaluate the productivity of the other species.

The fisheries monitoring plan and its results will be reviewed annually by a multiagency response team to ensure that sufficient, relevant information is collected. This will provide for increased specificity and focus when needed, and prevent the collection of inappropriate data. The multiagency response team will consist of the same members that are currently developing the monitoring plan. The response team will make recommendations about plan modifications. Monitoring techniques, parameters, and frequencies will also be part of the recommendations that this group will make to the responsible official. This same group will be responsible for the review and interpretation of information collected under the plan.

5.0
PREPARERS & CONTRIBUTORS



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This EIS for the Quartz Hill Molybdenum Project Mine Development was prepared by Envirosphere Company, a division of Ebasco Services Incorporated, as a third-party EIS for the United States Department of Agriculture, Forest Service. Envirosphere has responsibility for completion of the EIS under the direction of the Forest Service. Envirosphere Company has utilized several subcontractors in the preparation of this EIS. The Forest Service was responsible for review and acceptance of the EIS.

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6.0
GLOSSARY & ABBREVIATIONS

6.0 GLOSSARY AND ABBREVIATIONS

Within the body of the EIS, a number of technical topics are discussed. While every effort has been made to present these topics in language understandable by the lay public, some use of technical terms is inevitable. The following list of terms and abbreviations used in the EIS is for the non-technical reader who may wish to have certain terms defined.

A

AAC - Alaska Administrative Code

Abandonment - Discontinuing project operation, salvaging project facilities and rehabilitating the site when future mining is determined to be technically or economically infeasible.

ac - acres

ACMP - Alaska Coastal Management Program

Acre-foot (ac ft) - The amount of water which covers an acre of land to a depth of one foot; equal to 325,827 gallons.

ADCED - Alaska Department of Commerce and Economic Development

ADCRA - Alaska Department of Community and Regional Affairs

ADEC - Alaska Department of Environmental Conservation

ADF&G - Alaska Department of Fish and Game

Adit - A horizontal, or nearly horizontal, passage driven from the surface for the working or unwatering of a mine.

ADNR - Alaska Department of Natural Resources

ADOT - Alaska Department of Transportation and Public Facilities

ADPDP - Alaska Division of Policy Development and Planning

Advection - The horizontal movement of a mass of air that causes changes in temperature or in other physical properties of the air.

Ag - Silver

Airshed - An area of land over which the pattern of air movement is influenced by major topographic features.

Alevin - A newly hatched salmon with the yolk sac still attached.

Allochthonous - Of or pertaining to material generated outside a particular habitat but brought into that habitat, such as debris brought into the fjord by the rivers and streams tributary to it.

Alluvium - A general term for material deposited by streams; includes gravel, sand, silt, and clay.

Alpine - Pertaining to high altitude habitats, or to the vegetation or wildlife inhabiting those habitats, especially above timberline.

Ambient - The environment as it exists at the point of measurement and against which changes (impacts) are measured.

Amphipod - A large order of crustaceans found in freshwater, marine, and terrestrial habitats (over 4300 species); mostly scavengers.

Anadromous - Fishes which spend most of their lives in salt water but which migrate to fresh waters to spawn.

ANILCA - Alaska National Interest Lands Conservation Act - Public Law 96-487

Anoxic - A deficiency of oxygen.

Aquatic - Growing, living in, frequenting or taking place in water; in this EIS, used to indicate habitat, vegetation or wildlife in freshwater.

Aquifer - A water-bearing layer (stratum) or rock, sand or gravel.

As - Arsenic

ASAAQS - Alaska State Ambient Air Quality Standards

Aspect - The direction toward which a slope faces.

Atmospheric Stability Class - Six classifications to characterize the potential for air pollutant dispersion.

Attainment Area - A geographic region within which National Ambient Air Quality Standards (NAAQS) are met; three categories of attainment are defined - Class I, Class II and Class III - on the basis of the level of degradation of air quality which may be permitted.

Autochthonous - Pertaining to materials generated within a particular habitat (e.g. phytoplankton within a fjord).

Autotrophic (or autotroph) - Organisms that manufacture all their food (e.g., plants).

B

Ba -Barium

Background - The distant part of a landscape located from 3 to 5 miles to infinity from the viewer.

BACT - Best available control technology; pollution control as defined by EPA for a specific emission or pollutant stream and required for meeting pollution control regulations.

Baseline Studies - Studies of near natural environmental (i.e. physical, biological, social, and economic) conditions used as a basis for comparison with studies done on similar areas where various types of uses and practices have been or will be applied.

Basin - The drainage area of a river and its tributaries.

BAT - Best Available Control Technology Economically Achievable

Bathymetry - The measurement of depth of water in oceans, seas or lakes.

BCT - Best Conventional Pollution Control Technology

Benthic - Pertaining to the bottom, or to the inhabitants of the bottom, in seas or lakes.

Benthos - All animals and plants living on the bottom of a sea or lake, from water's edge to greatest depths.

Big game - Large animals hunted, or potentially hunted, for sport.

Bioaccumulation - Pertaining to concentration of a compound, usually potentially toxic, in the tissues of an organism.

Biodegradable - Capable of being broken down by the action of living organisms such as micro-organisms.

Biogenic - Produced by living organisms.

Biomagnification - Pertaining to concentration (bioaccumulation) up through the food chain of potentially harmful compounds, with each higher level in the food chain subject to higher concentrations of the material than would be expected on the basis of uptake and loss rates.

Biomass - The amount (weight or mass) of living material.

Bloom - "Excessive" growth of plankton, often resulting in visible scums, slimes or coloration of the water.

BMP - Best Management Practices

BOD - Biological oxygen demand; an indirect measure of degradable materials in the environment.

Boreal forest - A northern forest.

Brachiopod - A phyla of lophophorates commonly called lamp shells with the characteristic u-shaped feeding organ called a lophophore.

C

CAD - Mining Development Concepts Analysis Document

Calanoid Copepod - A subdivision of the subclass copepod that is distinguished by the length of antennae and body segmentation; representatives are largely free-living and planktonic.

Capelin - A small marine fish belonging to the smelt family.

Carnivore - A flesh-eating animal

Carrying Capacity - The ability of a habitat to support part or all of a population's life cycle.

Catch-per-unit-effort - Total number of fish caught divided by total number of trawls, an indirect measurement of relative population sizes; if species are tagged and released, subsequent recapture in later trawls may allow calculation of population size, fish life history, etc.

Cd - Cadmium

CEC - Cation exchange capacity

CEQ - Council on Environmental Quality

CFR - Code of Federal Regulations

cfs - cubic feet per second

cfs/mi^2 - cubic feet per second per square mile

Char - Closely related to trout, the char genus (Salvelinus) comprises Dolly Varden in the project area.

Chironomids - A large family of minute, delicate, non-biting, mosquito-like insects; midges, adults often swarm; larvae mostly aquatic.

Chlorophyll-a - A green pigment in plants which enables plants to convert carbon dioxide and water into carbohydrates.

Circular Mil - A measure of curcumference commonly applied to electrical transmission cables and conductors; one mil is 1/1000th of an inch.

Cirque - A deep, steep-walled basin on a mountain, shaped like half of a bowl.

Cladocera - A suborder in the class crustacea that are commonly called water fleas.

cm^2 - square centimeters

cm/sec - centimeters per second

Co - Cobalt

Coastal Downwelling - Convectional sinking of surface waters near an oceanic coast.

Colloidal Material - A suspension of fine particles (5 to 5,000 angstroms) in water.

Colluvial - Soil material that has moved downhill and has accumulated on lower slopes and at the bottom of a hill consisting of alluvium in part and also containing angular fragments of the original rocks, i.e. cliff debris, material of avalanches.

Conifer - A broad classification of trees, mostly evergreens, that bear cones and have needle-shaped or scalelike leaves; timber commercially identifed as softwood.

Copepod - A subclass of crustaceans, microscopic, common in marine and fresh waters (about 6300 species).

Cover - Living or non-living material (e.g., vegetation) used by fish and wildlife for protection from predators, to ameliorate conditions of weather, or reproduce.

Corps - U.S. Army, Corps of Engineers

Cr - Chromium

Criteria - Measurements which are used to examine or establish the relative degrees of desirability among alternatives or the degree to which a course of action meets an intended objective.

Criteria Pollutant - One of seven pollutants (SO_2, TSP, CO, O_3, non-methene HC, NO_x, Pb) for which National Ambient Air Quality Standards have been established.

Critical Habitat - Habitat determined to be essential to the continued survival and reproductive well-being of species of special concern, must be identified for each candidate for listing as threatened or endangered species.

Cu - Copper

cu ft - cubic feet

Cutoff Grade - Lowest grade of mineralized rock that qualifies as ore in a given deposit; assay grade below which an ore body cannot be profitably exploited.

cu yd - cubic yards

D

dBA - A unit for expressing the relative intensity of sound (decibel or dB), weighted along the audible frequencies.

DEC - Alaska Department of Environmental Conservation

Decommissioning - Suspension of operations for an indefinite but extended period of time with anticipation of resumption at a later date.

Decapod - The largest order of crustaceans which includes marine, freshwater, amphibious and terrestrial species including some of the largest and most highly specialized species.

De minimus - A rate of emission, in tons per year (tpy), set by regulation, which if not exceeded by a source is exempted from PSD review.

Demersal - Pertaining to organisms living on or near the bottom sediments of water bodies.

Detritivorous (or detritivores) - Organisms that primarily or totally rely upon particulate organic carbon for their food (includes certain species of marine clams, worms, etc.).

Detritus - Fine organic particulate debris.

Dewatering - The reduction of aquatic habitats by diversion of stream flow.

Diatom - Microscopic unicellular or colonial algae which have silicified skeletons.

Dinoflagellate - A microscopic single-celled organism in the phylum Protozoa; flagellate.

Distributary - A river branch flowing away from the main stream.

DO - dissolved oxygen

DOC - Dissolved Organic Carbon

Drawdown - The lowering of a reservoir's water level by discharge through its dam; also the lowering of the groundwater table locally by pumping a well or group of wells (wellfield).

E

EC-50 - The concentration at which an effect is produced on 50 percent of the test organisms.

EIS - Environmental Impact Statement

El Nino - A warm, Pacific coastal current travelling northward from Peru.

Endangered Species - Any species which is in danger of extinction throughout all of a significant portion of its range.

Entrainment - To draw in and transport (solid particles, water or gas) by the flow of a fluid or gas.

EPA - Environmental Protection Agency

Epibenthos - Organisms living on the sea bottom between the low tideline and 100 fathoms (600 feet) depth.

Epicenter - The part of the earth's surface directly above the focus of an earthquake.

Epifauna - Fauna living on the surface of bottom deposits in the sea.

Epipelagic area - The portion of the pelagic zone extending downward from the surface to 200 meters.

Epiphytes - Plant life such as lichens and mosses that grow on the surfaces of other plants.

Erosion - The wearing away of the land surface by running water, wind, ice, or other geological agents.

Escapement - The number of adult anadromous fish (e.g., salmon) that escape fishing pressure and enter their natal streams to spawn.

Estuary - Semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater from land drainage.

ET-50 - The time it takes for a response to show in 50 percent of the organisms.

Ethnographic - Pertaining to descriptive anthropology.

Ethnohistory - The history of a cultural group.

Euphausiid - Krill, a shrimp-like crustacean.

Euphotic Zone - That zone in a water column defined by the penetration of light in sufficient quantities to allow photosynthesis.

F

°F - degrees Fahrenheit

Fe - Iron

Fen - Lowland covered wholly or partly with water.

Filter Feeder - An animal that obtains its food by filtering it from the water by use of specialized appendages (i.e. barnacles use their legs) or gills (i.e. clams, some fish).

Fines - Fine particulate matter, specifically particles less than 0.4 mm in diameter.

Fjord - Narrow, deep, steep-walled inlet of the sea, formed either by the submergence of a mountainous coast or by entrance of the sea into a deeply excavated glacial trough after the melting away of the glacier.

Flocculation - To aggregate into lumps, the electrostatic bonding of charged particles. Physical-chemical forms of particles and chemicals may be stable in freshwater and destabilize on passing into higher ionic strength of the seawater medium.

Flue Gas - The gaseous emissions from a chimney or stack.

Fluvial - Of or relating to a stream or river.

Food Chain - A group of organisms linked linearly by predator-prey relationships.

Food Web - The complex interrelationship of organisms in a community with reference to feeding habits.

Foreground - Generally the area that lies within one-fourth mile of the view; details such as stumps and rocks being readily visible.

Forest Service - United States Department of Agriculture, Forest Service

ft - feet

Fugitive Dust - Dust particles resuspended randomly from road travel, excavation and rock loading operations.

Fry - A recently hatched fish.

G

Gammarid Amphipod - The largest suborder of amphipods, most of which are bottom-dwellers. Includes marine species and all of the freshwater species.

Glide - A calm stretch of water flowing smoothly.

Gneiss - A foliated, metamorphic rock corresponding in composition to granite.

gpd - gallons per day

gpm - gallons per minute

Granodiorite - A plutonic (or subsurface, igneous) rock containing of quartz minerals.

H

ha - hectares

Habitat - The natural environment of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influence affecting life.

Harpacticoid Copepod - A subdivision of the subclass copepod that is distinguished by the length of antennae and body segmentation; representatives are largely benthic.

Heavy Metals - A group of elements, usually required by organisms in trace amounts that are often toxic in higher concentrations; includes copper, lead, mercury, molybdenum, nickel, cobalt, chromium, iron, silver, etc.

Herbivorous (or herbivore) - An animal that primarily or totally consumes plants for its food.

Hertz - A measure of frequency in cycles per second.

Hg - Mercury

Holocene Period - The recent geologic period.

Hydraulic conductivity - A measure of the ability of rock or soil to permit the flow of groundwater under a pressure gradient; permeability.

I

IDT - Interdisciplinary Team

Igneous - Heat-formed rock.

in - inches

Increment - An increase in ambient air pollutant concentration, above the existing concentration.

Infauna - Burrowers in the bottom deposits of the sea.

In situ - A Latin term meaning "in place", in the natural or original position.

Interstitial - Occupying the spaces between sediment particles.

Intertidal - The zone of sea bottom between the low and high tide lines.

Intrusive - Rock having been forced into cavities between layers while molten.

Invertebrate - An animal lacking a spinal column.

Isopod - A large order of crustaceans with characteristic dorsoventrally flattened body; found in marine, freshwater and terrestrial habitats.

Isopycnical - A line of equal or constant sea water density.

Isostatic Rebound - An uplift of continental crust previously depressed by glaciation or some other overburden.

K

KGB - Ketchikan Gateway Borough

Kilovolt - One thousand volts; a volt is a unit of potential difference, and represents the electromotive force resulting under given current and resistance factors.

km - kilometers

km^2 - square kilometers

L

lbs - pounds

LC-50 - The concentration at which mortality is produced in 50 percent of the test organisms.

Ldn - 24-hour A-weighted equivalent sound level with a 10-decible upward weighting applied to nighttime hours (2200 to 0700 hours), in dBA.

Leq - Sound level of a constant sound which has the same energy as the actual time varying sound measured over a given time interval, in dBA.

Lignin - A substance related to cellulose that, together with cellulose, forms the wood cell walls in plants.

Limacina - A pelagic species of gastropod that is commonly called a shell-bearing sea butterfly (pteropod).

Littoral - The aquatic environment to which light can penetrate. Usually pertains to benthos.

M

m - meters

m ton - metric ton

m^3 - cubic meters

Macrofuana - An animal (or animals) large enough to be observed without magnifying aids.

Macrophytes - Large plants.

Marsh - Soft, wet land characteristically vegetated with grasses or cattails.

mcf - million cubic feet

Meadow - Moist, lowlying grassland.

Megawatt (MW) - A megawatt is a million watts or a thousand Kilowatts and is used to measure the amount of electricity that can be produced by a power plant at any one time; often abbreviated as Mwe or MW.

Meroplankton - Plankton which are only in the plankton part of the time (i.e. species which, due to vertical movement, are in plankton part of the day and are bottom dwellers the rest of the time) or species which are planktonic for part of their life cycle (i.e. planktonic larval stages of benthic or nektonic adult species). For example, Dungeness crab, clams, and flatfish have meroplanktonic larvae.

Mesopelagic Area - The portion of the pelagic zone extending downward from 200 to 1,000 meters.

Mesozoic Age - A geologic era lasting from the end of the Paleozoic Era (230 million years B.P.) to the beginning of the Cenozoic Era (60 million years B.P.).

Metamorphic - Geologically, rock formed by a change in physical (structural or substance) from by exposure to pressure, heat or water).

mg/l - milligrams per liter

$\mu g/m^3$ - micrograms per cubic meter

mi - miles

Microbiological Leaching - The action of bacteria, fungi and protozoans contributing to the solubility of certain chemicals.

Microzooplankton - Very small zooplankton, usually less than 0.5 mm in diameter but greater than 0.06 mm.

Middleground - The area between the foreground and background in a landscape. The area located from 1/4 to 1/2 mile to 3-5 miles from the viewer.

Migratory - Moving from place to place, daily or seasonally.

Migration Corridor - A belt, band, or stringer of vegetation what provides a completely or partially suitable habitat and which animals follow during migrations.

Migration Route - A travel route used routinely by wildlife in their seasonal movement from one habitat to another.

Mn - Manganese

Mo - Molybdenum

Modified Mercalli Scale - A descriptive means of rating earthquake severity, based on damage reported.

Mollusc - A phylum of soft-bodied animals normally partly or wholly enclosed in a calcium carbonate shell; includes snails, clams, oysters, mussels, squid, octopus (about 96,000 species).

Molybdenum (Mo) - A metallic element used in strengthening and hardening steel.

Molybdenum disulfide/Molybdenite - (MoS_2) The principal ore of molybdenum.

Monitoring - A watching, observing or checking, in this instance, a continuing testing of specific environmental parameters and of project waste streams for purposes of comparing with permit stipulations, pollution control regulations, mitigation plan goals, etc.

MOU - Memorandum of Understanding

mph - miles per hour

Multiple Use - The management concepts under which National Forest lands are managed. It involves the management of renewable resources in combinations that will best serve the public. Generally in any specific location a single resource will tend to have dominance over the others and will be more influential in determining management goals and direction. On a large land base, the collective utilization of the varied resources consititutes multiple use of the forest.

Muskeg - A bog characterized by sphagnum moss, often in tussocks (rising above the normal elevation), and a thick deposit of partially decayed vegetable matter below the moss.

MW - Megawatt

Mysid - An order of crustaceans found in marine and freshwater habitats; most are filter feeders and often live in large swarms.

N

N - Nitrogen

NAAQS - National Ambient Air Quality Standards

National Register of Historic Places - A list (maintained by the National Park Service) of areas which have been designated as being of historical significance. The Register includes places of local and state significance as well as those of value to the nation.

NEPA - National Environmental Policy Act.

New Source Performance Standards - Standards set by EPA defining the allowable pollutant discharge (air or water) and applicable pollution control for new facilities; by industrial category.

Nephelometric Turbidity Unit (NTU) - An index of how clearly light passes through water.

Ni - Nickel

NMFS - National Marine Fisheries Service

NOAA - National Oceanographic and Atmospheric Administration

NO_x - Nitrogen Oxide

NPDES - National Pollutant Discharge Elimination System.

NTU - Nephelometric Turbidity Unit

Nutrient - Substance furnishing nourishment.

O

ODCE - Ocean Discharge Criteria Evaluation

Odd-Even Year Run Cycle - Because pink salmon live and spawn only after 2 years, runs in even (e.g., 1980) and odd (e.g., 1981) years may be quite different in character and in size.

100-year Flood - A flood that occurs on the average once every 100 years.

Organism - Any living individual of any plant or animal species.

Outmigration - The seaward migration of anadromous fishes.

Overburden - Material overlying a deposit of useful geologic material.

Overhead Shield Wires - Grounded wires strung above the conductors of a transmission line to protect against lightning strikes.

P

P - Phosphorus

Paleozoic Age - A geologic era lasting from the late Precambrian Era (600 million years B.P.) to the beginning of the Mesozoic Era (230 million years B.P.)

Paragneiss - A gneiss derived from sedimentary rock.

Patent - A document conveying title to land from the U.S. Government to private ownership.

Pb - Lead

Pegmatite - Igneous rock of coarse grain found in subsurface dykes.

Pelagic - Of or pertaining to the open waters of the sea or fjords.

Periphyton - Plants that grow attached to underwater surfaces, especially algae.

pH - A notation designating acidity; a pH of 7 indicates neutrality; higher values indicate less acidity and lower values indicate more acidity.

Photic Zone - the region of a water body that receives sufficient light to support photosynthesis.

Photosynthesis - The process of converting carbon dioxide and water into carbohydrates in the presence of light and chlorophyll.

Phytoplankton - Planktonic plants, usually microscopic algae.

Piezometer - A device for measuring moderate pressures of liquids.

Piezometric Head - The level to which a liquid will rise in a piezometer, representing the static pressure of a water body.

Plan of Operations - A document, submitted for approval to the Forest Service, which describes the applicant's proposed project.

Plankton - Organisms suspended in the water of ponds, lakes, rivers or seas which are not independent of currents and water movements; usually microscopic.

POC - Particulate Organic Carbon

Pollution - Human-caused or natural degradation of water, air, or other aspects of the environment.

Polychaete - A class of annelid (segmented) worms (about 4000 species), mostly marine bottom dwellers which live in tubes or burrows in mud and sand.

Porosity - The porous property of a solid.

Preproduction - That period of mine development during which overburden is removed and the pit is opened but no ore is processed.

Primary Productivity - The measurement of photosynthesis.

Primary Standard - An air quality standard set for protection of public health.

Priority Pollutant - Toxic aqueous pollutants specified as of particular concern in the Clean Water Act; the responsibility of EPA is to set limits for discharge of these pollutants.

Pristine - Pertaining to pure, original, uncontaminated conditions.

Probable Maximum Flood - A flood calculated to be the largest probable under any circumstance.

Pycnocline - The plane of separation between two layers of water with differing densities, such as in a stratified system.

R

Ranney Well - A well in alluvial gravels, often within the floodplain of a river, where the water pumped in the well is "filtered" through the gravels from the river of the surface-fed water table.

Raptor - Bird of prey, including eagles, hawks and owls.

Reagent - A substance used to convert one substance into another by means of the reaction which it causes.

Rearing Habitat - That riverine or stream habitat where young fishes or other juvenile organisms feed and shelter prior to migration to adult habitat.

Recharge - In groundwater, to add to an aqufier via percolation of surface water or runoff through permeable strata.

Record of Decision - A document which discloses the decision on a major federal action and the reasons why the decision was made; it is signed by the official responsible for implementing the identified action. The environmental consequences disclosed in an Environmental Impact Statement are considered by the responsible official in reaching a decision.

Resident - A species, which is found in a particular habitat for a particular time period (i.e. winter resident, summer resident, year-round) as opposed to those found only when passing through on migration.

Resistivity - The potential of a body to resist the flow of liquids or energy.

Respiration - Production of energy by oxidizing carbohydrates to carbon dioxide and water.

Richter Scale - A numerical (logarithmic) measure of earthquake intensity.

Riffle - A shallow extending across a streambed and causing broken water.

Riparian - Pertaining to the shore of a lake or river.

Riparian Zone - An area identified by the presence of vegetation that requires free or unbound water or conditions more moist than that normally found in the area.

Riverine - Relating to, formed by, or resembling a river.

Runoff - Precipitation that is not retained on the site where it fell; natural drainage away from an area.

S

SAG Mill - Semi-autogenous grinding mill, a mill which uses the ore itself as a grinding medium and supplements with steel balls as required to obtain the proper size.

Salmonids - Fish species (salmon, trout and char) that belong to the same family, salmonidae.

Scrubber - Equipment used to remove pollutants (such as sulfur dioxides or particulate matter) from stack gas emissions.

Se - Selenium

Seasonal Cumulative Frequency Wind Rose - A graphic presentation of the percentage of time over a season that winds come from each of the 16 directions.

Secondary Standard - An air quality standard established for protection of public welfare.

Sediment - Material suspended in liquid or air; also, the same material once it has been deposited.

Sediment trap - A facility (e.g., an excavated basin or pond) of quiet water where suspended particulates can settle to the bottom, reducing sediment export to aquatic environments downstream.

Seiche - An oscillation, or wave, in a lake or lake-locked sea.

Seismic Refraction - Angular redirection of shock waves from an earthquake in differing densities of core or crustal material.

Seismicity - A measurement of earthquake vibration and/or occurrence.

Sensitive Species - A plant or animal listed by a state or federal agency as being of environmental concern; includes but is not limited to threatened and endangered species.

Sensitivity Level - A particular degree or measure of viewer interest in and concern for the scenic quality of the landscape. Three sensitivity levels are employed:

> Level 1 - Highest sensitivity. Includes all seen areas from primary travel routes, use areas and water bodies where at least one-fourth of the Forest viewers have a major concern for scenic qualities.

Level 2 - Average sensitivity. Includes all seen areas from primary travel routes, use areas, and water bodies where fewer than one-fourth of the Forest visitors have a major concern for scenic qualities. Level 2 also includes all seen areas from secondary travel routes, use areas, and water bodies where at least one-fourth and not more than three-fourths of the Forest visitors have a major concern for scenic qualities.

Level 3 - Lowest sensitivity. Includes all seen areas from secondary travel routes, use areas, and water bodies where less than one fourth of the Forest visitors have a major concern for scenic qualities.

Si - Silicon

Sill - Low part of a ridge separating ocean basins from one another or from the adjacent sea floor.

Slumping - Sliding of a mass of unconsolidated sediment down-slope. The sediment moves as a unit mass and often becomes a turbidity flow. Slumping may be triggered by slope instabilities or by earth shocks.

Smolt - A young salmon as it enters salt water.

Sn - Tin

SO_x - Sulfur oxides, including sulfur dioxide (SO_2).

SO_2 - sulfur dioxide

SPCC - Spill Prevention, Control and Countermeasure

Spawn - To produce and/or deposit eggs or sperm or the eggs or sperm product.

Specific Yield - The volume of water that will drain under the influence of gravity from a given volume of a porous medium; generally less than the porosity because capillary effects prevent total drainage at the pore space.

Specific Storage - The volume of water released from storage in a unit volume of aquifer per unit decline in potentiometric head. Specific storage is a function of the compressibility of the porous medium and the fluid saturating it, and, with the hydraulic conductivity, controls the relationship between production of water from the aquifer and reduction of potentiometric head until such time as the pore space of the medium begins to actually be dewatered.

sq cm - square centimeters

sq mi or mi^2 - square miles

SSRPT - Southern Southeast Regional Planning Team

Stratification - Layering, of waters, according to temperature, density, etc.

Streamflow - The discharge (flow of water) in a natural channel.

Stream Order - This is a gauge of stream size. A first order stream has no tributaries and is ordinarily small. A second order stream is formed by the joining of two first order streams.

Subalpine - The vegetation or habitat just below timberline.

Sublittoral - Aquatic environment below the depth to which light can penetrate. Usually pertains to benthos.

Surficial - The portion of the water column just above the sediment's surface.

T

Tailing(s) - Waste material separated from ore during the milling process; commonly has sand-like qualities.

Taxa - Categories or groups used in classifying plants and animals, such as species or families.

TDS - total dissolved solids

Tectonics - The branch of geological science concerned with structure, expecially folding and faulting.

10-year Recurrence Interval Flood - A flood that occurs on the average once every ten years.

10-year, 24-hour Event - The precipitation that is predicted to occur during a 24-hour period with a ten-year recurrence interval.

Third-Party Contractor - An independent firm contracted by a government agency to perform work related to a proposed action of another organization; due to the financial and contractual arrangements governing such relationships, the third-party contractor has no financial or other interest in the decision to be reached on the project. Envirosphere Company, a division of Ebasco Services Incorporated, is the third party contractor for this EIS. U.S. Borax, the project proponent, funds the work of Envirosphere, although the work is performed under the control and direction of the Forest Service.

Threatened Species - A wildlife species officially designated by the Fish and Wildlife Service as having its existence threatened.

Tidal Prism - The volume of water in the estuary removed and replaced during each tidal cycle.

Till - Unstratified glacial drift consisting of clay, sand, gravel and boulders intermingled.

TOC - Total organic carbon

Topography - A configuration of a surface including its relief.

tpd - tons per day

Trophic Level - One of the levels in a food web: producer or consumer, omnivore, carnivore or herbivore, etc.

TSP - Total Suspended Particulates

TSS - Total Suspended Solids or Sediment

Tsunami - A great sea wave produced by a submarine earthquake or volcanic eruption; commonly misnamed tidal wave.

Tunicate - A group of animals belonging to the phylum chordata that are also known as urochordates; includes sessile and planktonic forms.

Turbidity - Reduced water clarity resulting from the presence of suspended matter.

Turbidity current - A highly turbid, relatively dense current carrying large quantities of suspended material which flows down a submarine slope through less dense sea water.

U

U.S. Borax - United States Borax and Chemical Corporation

USDA - United States Department of Agriculture

USFWS - United States Fish and Wildlife Service

USGS - United States Geological Survey

V

Variety Classes (Visual Management System) - A particular level of visual variety or diversity of landscape character. Three classes are identified:

> Class A - Distinctive. Areas where features of landform, vegetative patterns, water forms, and rock formations are of unusual or outstanding visual quality.
>
> Class B - Common. Areas where features contain variety in form, line, color and texture or combination thereof but which tend to be common throughout the character type and are not outstanding in visual quality.

Class C - Minimal. Areas whose features have little change in form, line, color or texture.

Visual Management Objectives -

Preservation - This visual quality objective allows ecological changes only. Management activities, except for very low visual impact recreation facilities, are prohibited. It applies to wilderness, primitive areas, other special classified areas, areas awaiting classification and some unique management units which do not justify special classifications.

Retention - This visual quality objective provides for management activities which are not visually evident. Activities may only repeat form, line, color and texture which are frequently found in the characteristic landscape. Changes in their qualities of size, amount, intensity, direction, pattern, etc., should not be evident.

Partial Retention - This visual quality objective provides for management activities that repeat form, line, color and texture common to the characteristic landscape; but changes in their qualities of size, amount, intensity, direction, pattern, etc., remain subordinate to the characteristic landscape. Activities may also introduce form, line, color or texture which are seldom or not found in the characteristic landscape, but they will remain subordinate to the dominant elements existing in the landscape.

Modification - This visual quality objective provides for management activities that may visually dominate the original characteristic landscape. However, activity alteration must borrow from naturally established form, line, color or texture as such a scale that its visual characteristics are those of natural occurrences within the surrounding area or character type.

Maximum Modification - Management activities of vegetative and landform alterations under this alternative may dominate the characteristic landscape. However, when viewed as background the activity must appear as natural occurrences within the surrounding area of character type. When viewed as foreground or middleground, they may not appear to completely borrow from naturally established form, line, color or texture; or they may be out of scale with natural occurrences.

W

Waters of the United States - (a)(1) all waters which are currently used, or were used in the past, or may be susceptible to use in interstates or foreign commerce, including all waters which are subject to the ebb and flow of the tide; (2) all interstate waters including interstate wetlands; (3) all other waters such as intrastate lakes, rivers, streams (including intermittent

streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters: (i) which are or could be used by interstate or foreign travels for recreational or other purposes; or (ii) from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or (iii) which are used or could be used for industrial purposes by industries in interstate commerce; (4) all impoundments of waters otherwise defined as waters of the United States under this definition; (5) tributaries of waters identified in paragraphs (1)(1)-(4) of this section [definition]; (6) the territorial sea; (7) wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a)(1)-(6) of this section [definition]. Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA [Clean Water Act] (other than cooling ponds as defined in 40 CFR 123.11 (m)) which also meet the criteria of this definition are not waters of the United States.

Wetlands - Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, etc.

Wilderness - Land designated by Congress as a component of the National Wilderness Preservation System.

Wind Rose - A diagram showing the relative frequency of winds blowing from different directions.

Y

Young-of-the-Year - For fish and wildlife, the group of young produced in a given year.

Z

Zn - Zinc

Zooplankton - Planktonic animals

7.0
REFERENCES

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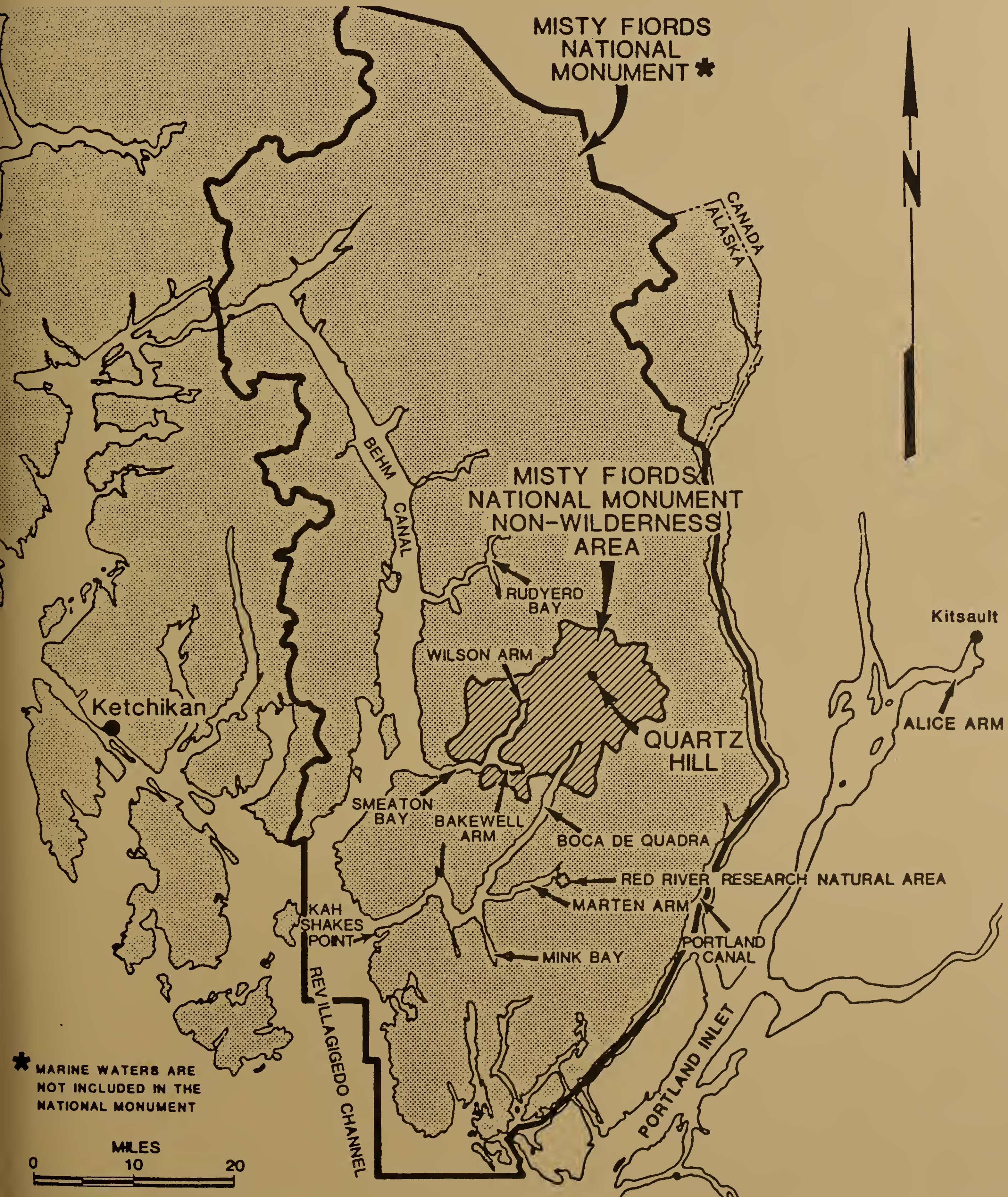
8.0
LIST OF AGENCIES, ORGANIZATIONS, & PERSONS TO WHOM COPIES OF THIS STATEMENT ARE SENT



8.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS STATEMENT ARE SENT

The following organizations are on the mailing list and will receive the Environmental Impact Statement.

Alaska Department of Commerce & Economic Development
Alaska Department of Community & Regional Affairs
Alaska Department of Environmental Conservation
Alaska Department of Fish & Game
Alaska Department of Labor
Alaska Department of Natural Resources
Alaska Department of Transportation
Alaska Division of Forestry
Alaska Loggers Association
Alaska Miners Association
Alaska Power Administration
Alaska State Chamber of Commerce
Alaska State Legislature, Reference Library
Alaska State Library
Alaska Trollers Association
AMAX Western Headquarters
American Wilderness Alliance
Anaconda Copper Co.
Anaconda Minerals Company
Annette Natural Resources Center
Arctic Environmental Information and Data Center
ASARCO Incorporated
Bechtel Civil and Minerals, Inc.
Boyer Towing Company
Bureau of Indian Affairs
Bureau of Land Management
Canadian Broadcasting Corporation
Citizen Advisory Committee on Federal Areas
Climax Molybdenum Company
Colorado State University - College of Forestry
Cooperative Extension Services
Craig Public Library
Dames and Moore
Ellis Law Offices, Inc.
Exxon Minerals Company
Federal Highway Administration
Fluor Engineers, Inc.
Foss Alaska Line
Frank Orth and Associates
Friends of the Earth
Getty Oil Company
Goldbelt Inc.
Golder Associates
Haida Corporation

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Hyder Public Library
International Engineering Company
Juneau Public Library
KRSA Radio
KTKN/KATV
Kaiser Engineers, Inc.
Kennecott Minerals
Ketchikan Air Service
Ketchikan Central Labor Council
Ketchikan Community College
Ketchikan Daily News
Ketchikan Gateway Borough - Planning Department
Ketchikan Indian Corporation
Ketchikan Public Library
Ketchikan Public Utilities
Ketchikan Visitors Bureau
Mayor, City of Ketchikan
Mayor, City of Saxman
Mayor, Ketchikan Gateway Borough
Minerals Exploration Coalition
National Audubon Society
National Marine Fisheries Service
Petersburg Public Library
R.W. Beck and Associates
Sealaska Corporation
Sierra Club Legal Defense Fund, Inc.
Sitka Public Library
Soil Conservation Service
Southeast Alaska Conservation Council
Southeast Alaska Health Systems Agency
Southeast Alaska Seine Boat Owners and Operators
Southeastern Alaska Mountaineering Association
Southern Southeast Regional Aquaculture Association
Standard Oil Company of California
State of Alaska, Office of the Governor
Temsco Helicopter
The Ralph M. Parsons, Company
The Wilderness Society
U.S. Army Corps of Engineers
U.S. Borax & Chemical Corporation
U.S. Bureau of Mines
U.S. Coast Guard
U.S. Department of Commerce
U.S. Department of Housing and Urban Development
U.S. Department of the Interior, Environmental Project Review
U.S. Environmental Protection Agency
U.S. Fish & Wildlife Service
U.S. Geological Survey
United Fishermen of Alaska
United S.E. Alaska Gillnetters

University of Alaska, Institute of Marine Science
University of Washington, College of Fisheries
VTN Consolidated, Inc.
Wildlife Preservation Society
Wrangell Public Library

The mailing list contains a total of about 400 agencies, companies, organizations, and individuals interested in the project. The above list was current in September 1985.

9.0 INDEX

MISTY FIORDS NATIONAL MONUMENT *
CANADA
ALASKA
N
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MISTY FIORDS NATIONAL MONUMENT NON-WILDERNESS AREA
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WILSON ARM
ALICE ARM
Ketchikan
QUARTZ HILL
SMEATON BAY
BAKEWELL ARM
BOCA DE QUADRA
RED RIVER RESEARCH NATURAL AREA
MARTEN ARM
KAH SHAKES POINT
PORTLAND CANAL
MINK BAY
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PORTLAND INLET
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9.0 INDEX

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